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NATURAL IMMUNITY TO INFECTION AND RESISTANCE TO DISEASE, AS EXHIBITED BY THE ORIENTAL, WITH SPECIAL REFERENCE TO SIAMESE

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TWO TEXT FIGURES

In applying the principles of preventive medicine and hygiene to conditions as they are found in the Far East the health officer has not only to deal with a complex sanitary problem, which in its intricacy consists of bad water supplies, unheard-of methods of night-soil disposal, a complete inexistence of food-distribution supervision combined with an unlimited disregard for many other primary sanitary principles; but, also, he has first and last to overcome a prejudice, born of ignorance and superstition, which in its capacity to resist modern western theory and practice is simply Cyclopean. One who has never visited this part of the world, who has only second-hand knowledge of conditions as they actually present themselves, has not the remotest idea of what the actual state of affairs is. Parlor sanitarians are uncommonly successful in devising ways and means to be applied in combating the epidemic diseases, but practicing hygienists not infrequently discover the impracticability of many of the hard-and-fast rules as decreed, and in no place is this so pronounced as in the Orient.

My experience covers a period of five years. During that time I have, consciously and unconsciously, had my sanitary point of view considerably altered as regards this particular

part of the world. This is due to the natural immunity to infection and resistance to disease as exhibited by the Oriental. Nature produces rather remarkable results in the way of protection, and a full appreciation of that fact is of extreme importance to the sanitarian working in the Far East.

Let us first consider a few of the more-important food and water-borne diseases, of which the most important is cholera. This very serious disease must be considered as being and having been endemic in Siam for the last one hundred years. Although it is recorded as present in Java as far back as 1629, the first extensive epidemic outside India seems to have begun in 1817, and by 1820 had extended to China, having traveled via Burma, Singapore, and Manila. It does not seem remotely possible that this part of the country could have escaped the disease at that time, although in the literature Siam is not mentioned as suffering from cholera until 1906 as the result of the severe epidemic that started in India in 1900.

Topographically, climatically, and hygienically, Siam is an ideal spot for the propagation of cholera. A vast part of the country occupies an alluvial plain consisting of black, muddy, waterlogged clay extensively polluted with decomposing matter. The sanitation is very bad, and practically all water supplies are unfit for domestic use with the exception of that from the modern plant in the City of Bangkok proper, completed in November, 1914, the influence of which is shown in the table of the vital statistics of the recent epidemic. The practice of using untreated fresh human fæces for fertilizing purposes is common throughout the country and the distribution of foodstuffs is quite uncontrolled. From the foregoing it is evident that more-ideal conditions could hardly exist for the spread of an acute epidemic disease like cholera.

In studying the history of the last epidemic in the City of Bangkok during the period between December 7, 1919, and September 20, 1920, some interesting facts are presented. Referring to the table we find that the east side of the river is supplied with a pure water and the west side of the river with an impure water. The morbidity and the absolute mortality rates are significantly lower on the east side as compared with the west side, yet we find that the case mortality is higher on the east side than on the west. It might be argued that the greater number of cases would account for this, but in my opinion the reason is to be found in the fact that the people on the east side, having for the past few years used a perfectly

pure water, have lost a certain acquired immunity previously gained as the result of constantly using an infected water supply, while the people residing on the west bank of the river still retain their immunity.

TABLE 1.—*Cholera in Bangkok City.*

[December 7, 1919, to September 20, 1920.]

	East side of river with pure water.	West side of river with impure water.	Total.
Population	603, 126	72, 610	675, 736
Cases	829	684	1, 513
Morbidity per 1,000	1.376	9.42	2.23
Deaths	483	360	843
Case mortality per cent	58.26	52.63	55.71
Absolute mortality per 1,000	0.800	4.958	1.247

This reasoning is to a degree plausible, although it might be argued that an immunity gained naturally, as the above supposed immunity is theoretically set forth, would be of many years' duration; yet an artificially produced immunity to cholera is of very short duration and may be figured in weeks. Although serum reactions fail to demonstrate the presence of specific immune bodies in the circulating blood, it is not beyond a reasonable doubt that, in spite of such negative evidence, the body does possess a marked degree of resistance to the disease, sufficient at least materially to protect it.

Turning now to another important intestinal water- and food-borne disease, typhoid fever, our experience has been even more impressive. Having the advantage of observing thousands of patients every year as treated in one of the local charitable hospitals, there can be no doubt as to the value of our observation to the effect that during a period of five years only two genuine cases of typhoid fever have been recognized. We feel that our knowledge of the disease and our methods of diagnosis are comparable to those of other workers in the East. Observations of this kind are impressive and cannot but influence one who is a public-health executive in a country not yet willing to accept the primary principles of preventive medicine, let alone the finer administrative details. There is no doubt but that the people have, not in theory only, but in fact also, a marked degree of immunity to typhoid infection. In a series of 600 Widal reactions it was found that 15.5 per cent gave

positive results. From the histories of the entire series of cases it would be impossible to state with any degree of accuracy whether or not any of the subjects had ever had typhoid fever. The information elicited from a native in regard to his previous physical condition is of no practical value; at least that has been our usual experience with the lower-class Siamese. In view of the fact that we have, during a period of five years, observed no less than 35,000 patients with only two genuine cases of typhoid fever being diagnosed, and also that at least 15.5 per cent of all the people (based on 600 reactions) do possess specific immune bodies in their blood, we feel that these people now exhibit a marked degree of racial immunity to typhoid infection. This we think is the result of having for generations suffered from subinfections caused by the constant use of infected water and food.

Among the dysenteries we have found the bacillary types to be comparatively rare. On the other hand, amœbic dysentery is not at all uncommon. This tends to support the above observations. The complications of the disease are uncommon, only four cases of liver abscess having been recognized during the five-year period mentioned.

Of the inoculation group of diseases plague is the most important epidemic infection we have to deal with. The conditions for its propagation are ideal. There is an unlimited supply of food for the rodent population, and the housing facilities for the same are, as one might say, made to order. Considering the fact that plague has been endemic in the country for many, many years, and in view of the perfection of the conditions for its spread, it is really surprising that there are not more cases each year. From fig. 1 it will be seen that, since 1904 up to and including 1920, there have been only 1,722 cases in a population of over 600,000. From the same graph it will be noted that there is a marked tendency to follow a fundamental wave, the cases increasing in number as well as in severity and extending over a period of from three to four years. The number of cases for 1921 does not appear on the graph, but proved to be one of the lowest that we have had. If this fundamental periodicity is to continue, its recursion is to be anticipated during 1922 or 1923.

Fig. 2 is of interest in showing the relationship between the average monthly incidence, the mean atmospheric temperature, and the mean relative humidity.

As to any racial immunity that the native possesses to the infection it may be stated at once that serum reactions fail to demonstrate specific immune bodies in the blood. However, we feel absolutely assured that, should a European population be

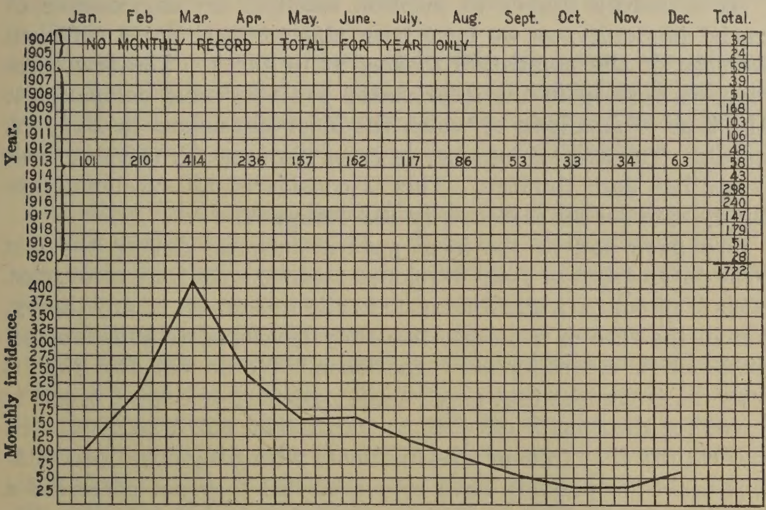

Fig. 1. Notified cases of plague in Bangkok, Siam.

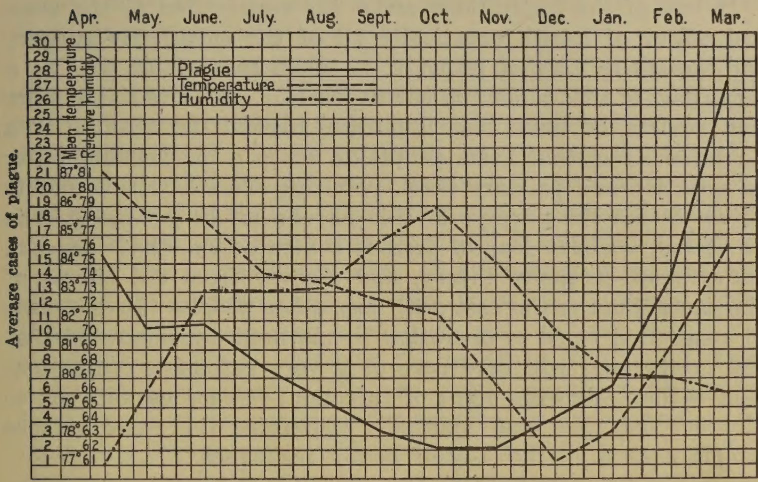

Fig. 2. Average monthly incidence of plague in Bangkok, Siam, during fifteen years, showing also the mean atmospheric temperature in degrees Fahrenheit and the mean relative humidity in percentages.

substituted for the native inhabitants and made to live under native conditions, the European population would be wiped out in a short time as the result of plague. As to some of the other important diseases, I submit the following remarks.

It is hardly proper to mention smallpox as an example of racial immunity, as we have been able to vaccinate a sufficient number of the population to keep it in check. The few cases that do develop in the unprotected are very mild compared to the type of smallpox of which the older physicians in Bangkok speak. The average number of cases per year for the last three years has been thirteen. This is considered an excellent morbidity rate for an eastern city like Bangkok.

We have had in the local general hospital during the last year seven cases of fully developed tetanus with four recoveries. This is of course a small number to cite in support of any theory, yet in the case of a disease like fully developed tetanus we feel justified in recording our experience. We do not feel that it was the treatment that saved these patients; of course, credit is given for the specific effect of the treatment, but it seems almost a certainty that four of these patients with fully developed tetanus could not possibly have recovered had they not possessed a great reserve of what may be termed "general infection immunity."

In one of the institutions under the supervision of the medical officer of health practically all of the emergency surgery for the entire City of Bangkok is taken care of, as well as a large part of that coming from the interior. To cite the number and variety of cases that illustrate, beyond the shadow of a doubt, the fact that these people do enjoy a marked immunity to infection and primary shock resulting from extensive bodily injury is not the purpose of this paper; but in general it may be stated, without fear of serious contradiction, that they can suffer more-extensive injury, and recover from the effects of the same, than is the case with any other people. In the class of cases that come to operation it has been demonstrated that the peritoneum will take care of a very extensive contamination without showing signs of infection. Space permits me to cite but one case that markedly illustrates the reserve these people possess in the way of bodily resistance.

Female patient, aged 32 years, native Siamese. Brought to hospital suffering from extensive stab wounds in abdomen. Injury so extensive that abdominal contents were protruding and wrapped up in an old dirty cloth. Patient several hours previous had been stabbed, wrapped in a

sheet and put into an earthen jar and the same thrown into a canal some 4 to 5 feet deep. Patient managed to escape from sheet and jar and reach the bank of the canal where she was found and brought to hospital.

Half of omentum amputated. Several large intestinal wounds repaired. Protruding abdominal contents washed with normal saline and replaced. Abdominal cavity not irrigated. Abdomen closed with one small drain.

Result, uneventful recovery.

The reader no doubt feels that this is a very exceptional case; but, as a matter of fact, cases of extensive injury and complete uncomplicated recovery are so numerous as to justify taking surgical risks that would not be legitimate in a white person.

Another interesting observation is the comparative lack of syphilis of the nervous system. Primary and secondary syphilis are rampant; but tertiary, and especially nervous, manifestations are so rare as to be absolutely exceptional. We have notes of only two cases of tabes, and in a local asylum for the insane where we have just completed a series of 544 specific serum reactions we find 17.2 per cent positive; yet the medical officer in charge reports that there is not, as far as he is able to recognize, a single case of insanity that can be traced directly to syphilis. This is certainly not due to any difference between the eastern and the western strains of spirochæte, as some authors seem to think. Unfortunately, syphilis of the nervous system is not at all uncommon in Europeans who have contracted their primary infection in Siam.

Of the respiratory group of diseases tuberculosis is, of course, the most important. Of the total deaths reported last year 12.5 per cent were reported as due to pulmonary tuberculosis. This percentage stands to be corrected, as we have been able to demonstrate that from 20 to 25 per cent of cases showing signs and symptoms of clinical tuberculosis are, in fact, either mycotic or spirochæte pulmonary infections. It is surprising that one does not find a greater number of pulmonary infections, considering the crowded quarters that thousands of people occupy. It seems that, given even a small chance, the body is to a very great extent able to overcome the tendency to lung infections. A corrected pulmonary death rate (tuberculosis) of 9.5 per cent is not considered alarming under existing conditions, and we feel quite sure that this rate will gradually reduce itself as sanitary conditions gradually improve. In other words, we feel that it is not necessary to carry on a special tuberculosis campaign if we can educate the masses to a point where they will appreciate and apply a few sanitary and hygienic principles.

Malaria should have been mentioned under the inoculation group of diseases, along with plague, but for a particular reason we wish to call attention to it now. We have been able to demonstrate malarial parasites, or evidence of them, in about 20 per cent of all of the patients attending a large free clinic in one of our hospitals. The subtertian parasite is frequently found, and we have had several cases of genuine quartan, but pernicious symptoms are infrequent. We have seen only eight cases of cerebral malaria; of these, one is a genuine case of multiple neuritis due to malaria. This is a rare and interesting observation. In view of the small number of cases exhibiting severe nervous symptoms it must be recognized that the nervous system of these people is very resistant to attack from the malarial parasite.

In connection with the nervous manifestations of diseases as observed, we wish to call attention to beriberi. This disease is much commoner in the City of Bangkok proper than in the interior of the country, no doubt due to the fact that in Bangkok the people eat fine-milled rice while in the interior the rice used is hand milled. This, of course, is not a new point in support of the deficiency theory as to the etiology of the disease; but another point is to be found, in my opinion, in the prominence of the nervous manifestations of the disease as found in the Siamese. I believe this is due to the fact that, beriberi being a deficiency disease, the nervous system along with the rest of the body must naturally suffer from a lack of vital food elements; whereas, if beriberi were the result of a germ infection, I do not think the nervous system of the Oriental would suffer as it does. We feel justified in advancing this as an important point in support of the deficiency theory as to the cause of the disease, in view of our careful observations regarding the effects of germ infection as a whole and the comparative immunity the Oriental nervous system displays to the same. We must, of course, mention the exception, leprosy, which is admittedly an important violation of the general rule; but we do not think this exception completely vitiates the value of further exploring this important field of investigation.

CONCLUSIONS

1. Specific immunity to typhoid infection can be demonstrated in 15.5 per cent of the people. This is in the nature of a racial immunity, acquired as the result of using, for many generations, an infected water and food supply.

2. Although resistance to certain diseases, such as cholera and plague, cannot be demonstrated by specific blood reactions, it is present in the form of a marked resistance to germ infections as a whole, that is, "general infection immunity."

3. The nervous system of Orientals is much more resistant to the effects of germ infection than is the nervous system of Occidentals.

4. The natural immunity to infection and resistance to disease, as exhibited by the Oriental, is of real value to the health officer working in the East under present conditions.

ILLUSTRATIONS

TEXT FIGURES

METABOLISM IN CHINA

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There has not been, as far as we know, a full scientific study of metabolism in China. Hence there are no records of the normal chemical constituents of the urine of the Chinese. Careful analysis has shown that it would be erroneous for the clinician to take the normal percentages given in western books as representing the normal for patients in China, and the two very brief lists of results published by Neale(11) and by Cousland(6) are so limited in character that we have felt it important to go into the matter more fully, making an examination of all the ordinary urinary constituents.

The first study was made upon convalescent surgical patients, who were living on a regular diet, low in protein. The results from diets containing small amounts of protein have been carefully investigated by various workers in recent years.(2) In seeking to try out and subsequently combat Chittenden's dietary standards, McCay,(9) of Bengal, has produced extensive and interesting work on the low protein diet of oriental peoples, showing how such a diet is sufficient to maintain the total protein store of the organism unaltered in amount on a nitrogenous supply that would be much below the amount decomposed during starvation; but he also adds that it is impossible to arrange a diet as low in protein content as Chittenden's standard that will not eventually prove insufficient and unsuitable. The figures in Table 7, for the Bengali students, show how low the amount of nitrogen was. It should be noted that he made no fair estimate of the endogenous metabolism and, with all his extensive food survey, he was unable to say whether or not the diets partaken were correct in character and of sufficient quantity to effect the full endogenous metabolism of a strong, healthy man, for he has no figures for creatinine and relied solely on the amounts of neutral sulphur obtained.

A similar set of results comes to us from Singapore, where J. Argyll Campbell,(3) in his work on the diet, nutrition, and excretion of the Asiatic, states that the results obtained from

the examination of urine indicate that the European figures are of little value when dealing with Asiatic patients. In Table 7 are summarized some of his results which show smaller volumes of urine and lower figures for total nitrogen, chlorides, and phosphates for the Asiatic, as compared with the European. He refers these differences entirely to climatic influence; heat and atmospheric moisture are said to account for the desire to lessen food and work, and the lessening of food brings poor physique and less muscular energy. The students of Singapore,(4) Manila,(1) and the Philippines generally have a smaller protein intake than the European, and this has been accounted for by the fact that climatic conditions require the maintenance of a smaller amount of body heat. Of the three, the Singapore student, with no seasonal change and a mean temperature of 80°, eats the least; but we must observe that his protein metabolism is about the same as that of the Pekingese.

The diet shown in Table 1 represents the average amount of food per diem taken by ten convalescent surgical patients. The actual amount of protein consumed was considerably less, for it was found that the patients did not actually get the amount of meat reported as being served to them. Hence the value of the report lies in the results of analyses of the daily urines. The diet is shown because, except for the amount of meat, the amounts of foodstuff may be considered accurate and show how other factors were taken care of.

TABLE 1.—*Diet of convalescent patients in 1920.*

Foodstuffs.	Breakfast.	Dinner.	Supper.	Totals per diem.
	g.	*g.*	*g.*	*g.*
Bread (wheat) or cooked rice	225	270	270	765
Millet gruel	995	455	455	1,905
Meat	25	25	25	75
Vegetables	100	150	150	400
Oil	15	20	20	55

Foodstuff per diem.	Protein.	Fat.	Carbohydrates.	Calories per diem.
	Per cent.	*Per cent.*	*Per cent.*	
Bread (wheat)	9.2	1.3	53.1	2,014
Gruel	0.86	0.01	5.71	501
Meat	15.6	30.9		260
Vegetables (as cabbage)	1.6	0.3	5.6	126
Oil		100		495
Total	[a]27.26	[b]132.51	[c]64.41	3,396

[a] 105.16 grams. [b] 89.44 grams. [c] 438.73 grams.

EXAMINATION OF URINES

Methods used for making examinations were the following:

Total nitrogen, estimated by Folin's micro method. Micro-Kjeldahl with subsequent Nesslerization.

Urea, soy-bean extract was used. After the action of the urease the ammonia was estimated by Folin's colorimetric method.

Ammonia, by aëration method.

Creatinine, by Folin's picric acid colorimetric method.

Uric acid, by Folin's method.

Chlorides, by Volhard's method.

Sulphates, by barium gravimetric methods.

Phosphates, by titration with uranium acetate.

TABLE 2.—*Summary of urine analyses of convalescent patients.*

Bed No.	Days.	Average volume.	Specific gravity.	Total nitrogen.	Urea nitrogen.	Creatinine.	Chlorides.	Phosphate.	Total sulphate.	Inorganic sulphate.	Total sulphur.
		cc.		*g.*	*g.*	*g.*	*g.*	*g.*	*g.*	*g.*	*g.*
1	8	2,336	1.019	9.42	5.32	0.784	10.21	1.548	2.034	1.909	2.970
2	4	1,690	1.025	5.12	2.42	0.710	9.75	1.061	1.209	1.051	2.019
3	7	1,674	1.022	5.67	3.13	0.643	7.05	1.322	1.646	1.517	2.583
4	10	1,630	1.021	5.07	2.57	0.452	5.72	0.686	0.842	0.727	1.704
5	5	1.930	1.022	7.32	4.43	1.254	9.18	1.156	1.699	1.571	2.691
6	8	2,341	1.023	10.20	4.93	0.786	7.29	1.324	1.822	1.599	2.699
7	5	1,462	1.025	4.77	1.93	0.765	7.47	1.094	1.387	1.256	1.703
8	6	1,403	1.032	9.07	5.16	1.261	-------	-------	2.164	2.087	3.282
9	5	2,123	1.022	5.68	-------	1.269	7.95	1.299	1.391	1.302	1.858
10	2	1,580	1.020	8.32	6.82	1.744	-------	-------	2.219	2.144	3.305
Average	60	1,817	1.023	7.06	4.08	0.967	8.08	1.186	1.650	1.516	2.481

Table 2 is full of interest as a study of low protein metabolism, it being in accord with other recent work along these lines where workers were able to subsist on as low an amount as 0.5 gram of nitrogen per kilogram of body weight, in wheat, maize, and oats. See the work of Sherman,(13) Rose and Cooper,(12) and many others.

The volumes of the urine excreted were the same as a normal western average. However, as the urines were collected in the winter months, they do not represent an average annual figure. In the summer time the volumes are extremely low.

ANALYSES OF URINES OF NORMAL INDIVIDUALS ON A NONFLESH DIET

Subsequently it was thought advisable to analyze the urines of four laboratory helpers who were in apparently good health,

and dependable for good coöperation in faithfully accounting for everything done. Their diet consisted chiefly of wheat, rice, and beans, and the food value of the average intake amounted to 3,264 calories per day.

The four subjects studied were natives of Peking, of about average weight, namely, a little over 50 kilograms.

TABLE 3.—*Analyses of urines of normal subjects on a nonflesh diet.*

Name.	Volume.	Specific gravity.	Total nitrogen.	Urea nitrogen.	Ammonia nitrogen.	Creatinine.	Uric acid.[a]
	cc.		g.	g.	g.	.	g.
A	850	1.028	8.820	6.876	0.850	1.264	
A	1,130	1.020	9.413	8.125	0.645	1.255	
A	1,220	1.026	9.211	7.272	1.109	1.499	0.725
A	700	1.027	6.300	4.739	0.672	1.138	
A	1,000	1.032	8.925	7.225	0.778	1.695	
B	730	1.030	9.424	7.764	0.937	1.278	0.667
B	1,150	1.021	9.480	8.439	0.761	1.035	
B	910	1.027	10.010	7.256	0.866	1.265	
B	730	1.023	7.738	5.881	0.569	0.924	
B	700	1.019	5.600	4.376	0.485	1.636	
C	1,150	1.025	7.530	6.026	0.579	0.927	0.582
C	740	1.033	7.622	6.190	0.655	1.010	
C	820	1.024	8.528	6.614	0.766	1.127	
C	1,140	1.024	9.593	7.555	0.695	1.169	
C	970	1.028	8.434	6.916	0.718	0.985	
D	1,130	1.023	9.855	7.381	1.087	1.460	
D	810	1.033	11.907	9.705	0.810	1.472	
D	830	1.045	11.027	7.557	0.783	1.434	
D	810	1.027	10.300	7.537	1.077		
D	960	1.026	11.289	7.856	0.860	1.286	
Average	924	1.027	9.05	7.064	0.761	1.193	0.691

[a] Average of ten determinations each.

ANALYSES OF URINES OF STUDENTS ON A NONFLESH DIET

Six students, taking the ordinary courses of instruction, provided reliable material for further experiments. They were living regularly on a good mixed diet, fairly rich in protein. It was thought to be of interest to compare the results obtained from such subjects when living on a nonflesh diet for a few days with the results from the four laboratory helpers whose regular diet includes no meat except that taken at special holiday times. The total nitrogen, urea, and ammonia values are approximately the same. Values for creatinine as they appear in Tables 2, 3, 4, 5, and 6 show marked differences, indicative of the endogenous metabolism, and to a certain extent a measure of physiological efficiency. One laboratory helper in normal health, but lacking stamina, gave no creatinine in his urine.

He regularly subsisted on a cereal diet. On several occasions hospital convalescents excreted no creatinine in the urine. Examinations were made in the regular manner, care being taken to see that no interfering factor was introduced; also satisfactory controls were made with solutions of known strengths of creatinine.

Statistics regarding students under observation.

	Nationality.	Birthplace.	Age.	Weight.
			Yrs.	*Kilos.*
A	Chinese	Chekiang	25	52.3
B	do	Hupeh	24	66.5
C	do	Canton	24	50.8
D	do	Kiangsu	22	([a])
E	do	Canton	21	41.8
F	do	Chihli	25	([b])

[a] Died. [b] Removed.

TABLE 4.—*Analyses of urines of students on a nonflesh diet.*

Name.	Volume.	Specific gravity.	Total nitrogen.	Urea nitrogen.	Ammonia nitrogen.	Creatinine.	Uric acid.
	cc.		*g.*	*g.*	*g.*	*g.*	*g.*
A	880	1.028	8.674	7.655	0.355	1.285	0.229
B	1,800	1.019	9.135	7.753	0.428	1.440	0.490
C	1,170	1.025	9.091	5.994		1.671	0.549
D	1,800	1.015	10.440	8.365	0.905	1.600	0.183
E	1,350		8.181	7.120	0.627		0.471
F	1,100	1.026	9.487	7.050	0.726		0.374
Average	1,350	1.022	9.168	7.323	0.608	1.499	0.382

ANALYSES OF URINES OF STUDENTS ON ORDINARY DIET AND ON A DIET OF AN EXCESSIVE AMOUNT OF MEAT

Further experiments were made with two other diets containing meat, in moderate and in excessive amounts. The terms moderate and excessive refer to Chinese ideas upon this subject. The students were all in good health, taking daily exercise at tennis or other games, and were living upon a normal, middle-class Chinese diet of about 3,500 calories. Such a diet contains a variety of foodstuffs made up into the usual soups and mixed dishes, in which the vitamines and essential proteins are well provided for by many lightly cooked vegetables and various chopped meats. In these experiments it was hoped that we might realize results comparable in nitrogen value to the European standard. However, they more nearly approach the results given by Campbell(3) for Singapore workmen, which he attributes to the heat and the humidity. Our results were

obtained in an exceedingly dry climate, and mostly during winter when snow was falling.

TABLE 5.—*Analyses of urines of students on an ordinary Chinese diet.*

Name.	Volume.	Specific gravity.	Total nitrogen.	Urea nitrogen.	Ammonia nitrogen.	Creat-inine.	Uric acid.
	cc.		*g.*	*g.*	*g.*	*g.*	*g.*
A 1	1,410	1.028	13.180	10.760	0.790	1.533	
A 2	1,200	1.029	12.000	10.697	0.727	1.568	
A 3	855	1.033	10.688	8.801	0.697	1.410	
A 4	955	1.030	5.730	4.860	0.445	1.327	
B	1,120	1.021	8.814	7.320	0.689	1.243	
C 1	1,195	1.022	9.321	7.310	0.657	1.195	0.3349
C 2	820	1.033	8.200	6.758	0.626	1.018	0.2534
D 1	1,460	1.027	12.264	10.177	0.773	1.536	
D 2	1,500	1.025	12.495	11.083	0.767	1.685	
E	1,210		9.680	8.260	0.773	1.291	
F	610	1.038	8.134	5.984	0.793	1.140	
G 1	1,500	1.021	11.535	9.853	0.857	1.500	
G 2	1,400	1.020	7.686	5.950	0.777	1.435	
H 1	1,480	1.020	9.546	8.337	0.743	1.396	
H 2	1,370	1.020	6.5713	5.604	0.732	1.556	
Average	1,205	1.027	9.852	8.082	0.727	1.373	

TABLE 6.—*Analyses of urines of students on an excessive meat diet.*

Name.	Volume.	Specific gravity.	Total nitrogen.	Urea nitrogen.	Ammonia nitrogen.	Creat-inine.	Uric acid.
	cc.		*g.*	*g.*	*g.*	*g.*	*g.*
A	1,110	1.031	12.130	10.310	0.699	1.655	0.305
B	1,300	1.030	13.728	11.492	0.696	1.898	1.300
C	770	1.031	17.265	15.400	1.091	1.540	0.394
D	1,200	1.026	12.000	10.483	0.857	1.632	0.583
E	950	1.025	12.330	10.156	0.920	1.826	0.468
F 1	1,400	1.022	10.891	7.189	0.861	1.582	0.546
F 2	900	1.032	9.900	7.177	0.833	1.503	0.513
Average	1,090	1.028	12.606	10.308	0.871	1.605	0.587

DISCUSSION OF RESULTS

Total nitrogen.—As observed by Campbell,(4) in all cases the absolute amount of nitrogen was much lower than that of the normal standard for Europe. However, nitrogen equilibrium has been maintained on very much lower values than those of the normal European standard, a number of modern laboratories having worked on vegetarian diets low in protein. The actual values are judged by the amount of total nitrogen per kilogram of body weight. The results from the normal diet of the students is considerably lower than for the European. Taking our average student weight as representing that of the other sub-

jects examined, the values for total nitrogen per kilogram of body weight would appear much lower still; namely, 0.132 for Chinese (Table 2) and 0.169 for Chinese (Table 3). Until further evidence is available we are led to support Campbell's and McCay's view that races who live for generations on low protein diet do not have the physique and energy of those whose diet contains more protein, especially protein from meat. With our present limited knowledge of the exact amino-acid content of our protein foodstuffs, any chance diet low in protein content is not likely adequately to care for the body's needs. The general lassitude of the people; their lack of initiative; their apathy in face of famines and floods, plagues, poverty, and military oppression appear to originate as much in poor diet as in political or educational poverty. Campbell (4) has attributed these defects to the bulk and indigestibility of the vegetable protein food, and to the tropical climate that induces men to work less and to desire less food. The latter factor certainly does not influence the northern Chinese, who experience very cold winters. They are industrious and consume large amounts of cereal food, because there are no good dairy farms to provide better food; and communications are so poor that they cannot look abroad for adequate provision for their needs.

Urea nitrogen.—Neale's (11) observations show the urea nitrogen to be about 21.87 grams in twenty-four hours. His results were based on determinations made by the bromine method, which is so unreliable as to admit of no discussion; the results from this method are usually too high. Our results are in accord with those of Campbell, showing that Folin's (7) estimate of about 79 per cent of the total nitrogen is the normal amount to be expected when the total nitrogen output falls to from 7 to 8 grams. However, our determinations, accurately made upon convalescent patients, show an extremely low percentage (see our discussion of ammonia nitrogen). In any case, no clinician should take the normal European standard as representing a Chinese standard.

Ammonia nitrogen.—Folin (8) observes that, when the total nitrogen excretion is only from 7 to 8 grams, the ammonia nitrogen forms about 5 per cent. Campbell, (5) using Malfatti's method, obtained higher percentages indicative of an acidosis which he attributed to a disturbance of metabolism caused by the hot moist air of the Tropics. In Peking, where the long winters are very cold and dry, we obtained even higher values for ammonia nitrogen. In the case of the convalescent patients

very high results were obtained, undoubtedly due to extreme acidosis.

The excretion of ammonia is regarded as the mechanism whereby the body rids itself of acids formed during metabolism. Some unpublished experiments conducted on urines from osteomalacia cases from Shensi Province show that the subjects had experienced extreme acidosis, causing the bases to be washed out of the system to such an extent that the urine eventually contained very little calcium and the whole structure of the frame was upset. The disease is called locally the acid disease, and is recognized by the lay mind as being related in some way to a disturbance of the acid base equilibrium of the body. Were this disease a rarity it would not call for mention here; but when vital statistics show that 20 per cent of the women of that province die either in or subsequent to childbirth, one is led to attribute the cause to some general factor like an acid-ash diet, injurious to both sexes but more conspicuous in the female. During the long barren winters of northern China the country people subsist on a very limited diet composed almost entirely of cereals. Cereals in general produce an acid ash and may well account for the high ammonia excretion of the Asiatic.

McCay(9) in his studies on Bengali prisoners found very high values; namely, an average of 9.61 per cent of the total nitrogen. In several individual cases, not reported here, very abnormal results were obtained—nearly as high as 20 per cent. Every care was taken to see that no errors were introduced. The urines were preserved, and methods of estimation carried out with normal foreign urines. The results with students' urines, while not quite so high as those for the Bengali prisoners, exceed those for the Chinese students in Singapore. The more-recent work of Campbell(5) on ammonia excretion leaves no room for doubt that the Asiatic has a high ammonia output. His ideas concerning its possible relationship to excessive sweating or to febrile disease are not supported by conditions in Peking; rather, the high output has been considered to originate from the diet, though one often finds intestinal parasites and intestinal disorders that cause putrefaction with a high degree of acidity. Facts concerning such possible causes have yet to be established. If such causes do exist one would look for high values for ethereal sulphates; however, our results show a normal percentage.

TABLE 7.—*Comparative nitrogen excretion of the various races.*

	Volume.	Specific gravity.	Total nitrogen.	Urea nitrogen.		Ammonia nitrogen.		Creatinine nitrogen.		Uric acid.		Creatinine coefficient.	Total nitrogen per kilogram of body weight.
	cc.		g.	g.	P. ct.	g.	P. ct.	g.	P. ct.	g.	P. ct.		g.
Chinese II; the poor class	1,817	1.023	7.06	4.08	57.7	----	----	0.363	5.05	----	----	----	----
Chinese III; skilled laborers	924	1.027	9.05	7.06	78.1	0.76	8.4	0.448	4.95	0.230	2.54	----	----
Chinese IV; students on non-flesh diet	1,350	1.022	9.168	7.32	79.8	0.61	6.7	0.563	6.15	0.127	1.39	10.5	0.164
Chinese V; students on moderate flesh diet	1,205	1.027	9.852	8.08	81.9	0.73	7.4	0.515	5.22	----	----	9.6	0.176
Chinese VI; students on excessive flesh diet	1,090	1.028	12.61	10.31	81.9	0.87	6.9	0.602	4.78	0.196	1.55	11.2	0.259
Malays in Singapore	(1,335)	(1.010)	8.74	6.89	78.91	0.69	7.91	0.440	5.08	0.170	1.91	7.8	0.154
Chinese in Singapore	(1,273)	(1.012)	8.60	7.02	81.63	0.54	6.28	0.360	4.26	0.140	1.63	8.7	0.208
Bengali students (McCay)	1,200	1.013	6.05	6.04	(?)	----	----	----	----	0.113	1.87	----	----
Bengali prisoners (McCay)	1,570	----	8.84	----	----	0.85	9.61	----	----	----	----	----	----
Europeans (Queensland, Young)	----	----	11.49	----	----	----	----	----	----	----	----	8.52–10.62	0.194
European standard (Halliburton)	1,500	1.020	16.00	13.60	85.00	0.53	3.30	0.570	3.6	0.25	1.56	7-11	0.200

Creatinine nitrogen.—The excretion of creatinine represents chiefly the endogenous metabolism of the body. Hence the coefficient (milligrams per kilogram of body weight) is an important factor. Our results resemble the European standard, though the absolute amounts excreted are far lower. The results, carefully and accurately worked out, are far below anything recorded for normal subjects, either in China or in Europe.

The excretions from vegetarian diets of the Chinese, Tables 2, 3, and 4, give three different average results for the amount of creatinine present in the urine, which on account of the diet is an index of the endogenous metabolism. The excessive flesh diet, Table 6, shows a marked rise in output of creatinine, undoubtedly exogenous in origin. The physique of the three Groups II, III, and IV follows the creatinine values. Group II consisted mostly of coolies or shop assistants in poor condition. Group III, our laboratory helpers, originated from the same class but all have attended school and in their present employment have regular meals, regular work, and leisure to recuperate. The students had the highest excretion, which would be expected on account of their much better physique, better food, regular sleep, and good athletics—all of which factors contribute to make them more fit than the average citizen. The absolute amount naturally increased when the students ate an excessive flesh diet, the increase being of exogenous origin.

It is probably true that, as Campbell(4) points out, the increase in tissue metabolism as judged by a greater creatinine output is not marked in a tropical climate, though it appears to be slightly lowered in our cold northern seasons. Such a deduction is in no way in accord with what would be deduced from the high values obtained for neutral sulphur.

Uric acid nitrogen.—The results in Groups IV and VI are similar, in absolute amounts and in percentage, to those from Singapore. Our values for Group III are abnormally high. This may be due to the drinking of large quantities of Chinese tea. There are no analytical data available to show whether the pale Chinese tea, which is rich in purines, increased the uric acid excretion or not.

Chlorides.—On account of the high price of salt in China, people there do not eat as much salt as Europeans do. Our values are consequently lower. One surgical eye patient, middle-

aged, in apparent good health, excreted no chlorides. He did not dislike salt. After we had administered two 10-gram doses, he excreted it freely in the urine.

Phosphates.—The ratio of phosphoric oxide to nitrogen for the subjects of Table 2 is 1 to 5.1, which is similar to that quoted for Europeans, namely, 1 to 5 or 6.

Sulphates.—The ratio of total sulphur to nitrogen is similar to that obtained by Young.(14) There was an average of 14.06. This is not remarkable when we consider that the ratios obtained vary according to the diet. The absolute amounts of inorganic and ethereal sulphates were fairly normal, indicating no abnormal putrefaction in the intestine; and, since our nitrogen-to-sulphur ratio is high, we conclude that about the normal amount of protein sulphur was oxidized. The proportion of neutral sulphur was very high, see Table 8. Folin(8) has shown how

TABLE 8.—*Excretion of sulphur.*

No.	Total nitrogen.	Sulphur. Percentage of total sulphur.						Nature of sickness.
		Inorganic.		Ethereal.		Neutral.		
	g.	*g.*	*P. ct.*	*g.*	*P. ct.*	*g.*	*P. ct.*	
1	9.42	1.909	64.3	0.125	4.21	0.936	31.5	Hernia and chest.
2	5.12	1.051	51.8	0.158	7.77	0.810	39.8	Multiple abscesses.
3	5.67	1.57	58.6	0.128	4.99	0.937	36.2	Wound in foot.
4	5.07	0.727	42.6	0.115	6.75	0.862	50.6	Septic leg.
5	7.32	1.571	58.4	0.128	4.75	0.992	36.8	Necrosis of tibia.
6	10.20	1.599	59.3	0.243	9.03	0.877	32.5	Tuberculosis in knee.
7	4.77	1.256	73.8	0.131	7.70	0.316	18.5	Tuberculosis of spine.
8	9.07	1.087	63.6	0.077	2.34	1.118	34.06	Gangrene of foot.
9	5.68	1.302	70.2	0.089	4.60	0.467	25.2	Spur of os calcis.
10	8.32	2.144	64.9	0.075	2.26	1.086	32.84	Scoliosis.
Average	7.06	1.516	61.16	0.125	5.04	0.840	33.0	

the amount of neutral sulphur excreted is practically independent of the diet. In his experiment a patient on a normal protein diet gave 0.18 gram, or 4.8 per cent of the total sulphur, and the same person on a reduced protein diet gave 0.2 gram, or 26.3 per cent of the total sulphur. It is a known fact that anæsthetics will increase the amount of neutral sulphur; however, not all of our patients were operated upon, but all show high values. In any case, none of the urines were collected until the patients were well on the road to recovery and convalescing, just before being discharged. Case 4, which gave an average

of 50.6 per cent from duplicate determinations on ten successive days, is noteworthy. The determinations were made up to the day the patient left the hospital. It is thought possible that, as the Chinese are exceedingly fond of garlic, onions, and cabbage these foods may be related in some way to this exceptionally high excretion of neutral sulphur.

SUMMARY

1. Analysis of the chemical constituents of Chinese urines excreted by various classes of people taking different diets has been made.

2. The results have been compared with those obtained for Europeans, subjects of India, Asiatics in Singapore, and Europeans in Queensland.

3. The absolute quantities of nitrogen and urea are low, being similar to the results obtained by Campbell(4) for Asiatics in Singapore. He attributed these low results to the indirect effects of heat and humidity. Our results were obtained in a dry cold season, and we consider diet to be the sole reason for such low results.

4. The percentage of ammonia nitrogen is far above the European normal but agrees exactly with Campbell's(5) and with McCay's(10) findings. Disregarding climate, we believe high cereal diets to be the cause, or it may be a racial characteristic.

5. The Chinese do not excrete large amounts of chlorides. Bunge's theory that vegetarian diets produce a greater craving for salt can be ignored in a country where goverment monopoly makes salt a luxury.

6. Values obtained for neutral sulphur were very high. Young,(14) of Queensland, obtained similar results, from which he declined to draw any definite conclusions. We again suggest dietary causes, introducing an exogenous rather than an endogenous factor.

7. Our results in general confirm those of others working on Asiatic subjects. The environments being so different we conclude that heat and humidity are not the controlling factors.

8. Definite conclusions concerning the seeming abnormalities of Asiatic metabolism are deferred until abundant data have been collected from a variety of sources in the Orient.

9. Clinicians working in the Orient should adjust their standards in chemical analysis accordingly.

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A NEW GENUS AND SPECIES OF FLY REARED FROM THE HOOF OF THE CARABAO

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Genus BOOPONUS[1] novum

Female only.—Eye rather small, bucca (below) equal to half its height; front one-third of head width, the median stripe occupying two-thirds its width. Ocellar bristles well developed, strongly divergent; verticals two pairs, the inner convergent. Frontal bristles about fourteen in the row, reaching the middle of second antennal joint, the uppermost one diverging strongly to the side, the next just as strongly to the middle, and the following ones like it but gradually more erect. Interfrontals absent. Two small orbitals placed high up, opposite second and third frontals. Outside the frontals a uniform covering of small black hairs, which extend downward covering the parafacials and bucca except a small space outside of and above the vibrissæ. Facial ridges with larger hairs nearly halfway up. Vibrissæ hardly more than half as far apart as the facial ridges at their middle. Face much depressed, the ridges high and sharp. Antennæ of ordinary form, not large. Arista strongly thickened on basal two-fifths, penultimate joint short, bare below, pectinate above with short hairs which at longest are hardly double the thickness of the arista. Palpi normal; proboscis short, with ordinary labella.

Thorax with a row of half a dozen hypopleural bristles; sternopleurals, 2; acrostichals, 2 or 3 anterior, 3 posterior; dorsocentrals, 2, 3; humerals, 3; interhumerals, 1; posthumerals, 2; presuturals, 2; notopleurals, 2; intra-alars, 3; supra-alars, 2; postalars, 2; scutellars, 4 pairs lateral in a straight row of which the last and largest is apical, and 3 or 4 pairs above them which become subdiscal toward the tip. Hind calypter bare, twice as wide as front one. Pteropleura with hairs and a very small bristle.

Abdomen without macrochætæ, covered with uniform black hairs like those on the head; hind edge of all four segments

[1] Βωυς, the ox; κωνωψ, affliction, torment.

with a row of longer hairs, not conspicuous. Sternal plates uncovered.

Legs weakly bristled; mid-tibia at last fourth with one small bristle on inner side and one on outer front; on the outer hind are two small bristles.

Wing with first posterior cell narrowly open almost in the apex, the third vein bearing nine or ten setules at base, its last segment bulging forward in and beyond the middle, then curving backward; fourth vein with a broadly rounded double curve, near tip becoming almost parallel with third; no costal spine.

As far as can be judged from a female, the genus is somewhat allied to *Cordylobia*, but differs in having the arista not plumose, etc. I can find no genus of testaceous flies with an arista like the one here described. The three specimens examined vary in regard to the third pair of anterior acrostichals, which when present stand just in front of the suture; one specimen has them present, one absent, and in the third a single bristle is present, its mate absent. This character is generally of importance, as Villeneuve has used it to separate his Xanthocalliphorinæ (his Testaceæ sens. str.) from Eucalliphorinæ (*Calliphora* etc.).[2]

Booponus intonsus sp. nov.

Female.—Wholly light yellow, including tarsi, except a trace of brownish on the anterior part of the thoracic dorsum. Front 0.32 of the head width. Wings subhyaline with yellow veins. There are numerous short, evenly placed black hairs, not only on the front, face, and bucca (suggesting the specific name), but also on the femora and whole abdomen, and even interspersed with the bristles on the mesonotum and scutellum.

Length, 6.3 millimeters.

Described from three female specimens reared at Los Baños, Laguna Province, Luzon, from the hoof of the water buffalo.

Type, female, catalogue No. 25646, United States National Museum.

[2] Bull. Soc. Ent. France No. 14 (1920) 223–225.

THE FOOT MAGGOT, BOOPONUS INTONSUS ALDRICH, A NEW MYIASIS-PRODUCING FLY

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EIGHT PLATES

In the routine work of laboratory diagnosis on the cases in the clinic of the College of Veterinary Science of the University of the Philippines, a peculiar type of myiasis-producing fly was discovered. From clinic case 109 (carabao) a number of maggots were obtained which were strikingly different, both in appearance and in habit, from the other types of fly larvæ which had been previously observed. Adults raised from these maggots were forwarded to Dr. J. M. Aldrich, of the Smithsonian Institution, through Dr. L. O. Howard, chief of the Bureau of Entomology of the United States Department of Agriculture. Doctor Aldrich reported the fly to be a previously undescribed species, and one for which a new genus must be erected. It has since been described by him as *Booponus intonsus*.[1] Subsequent to the recognition of this distinct type of myiasis, several interesting cases have been treated in the clinic of the College of Veterinary Science, which have furnished excellent oportunities for a detailed study of this peculiar fly.

CASE REPORTS

1. *Case 109, February 16, 1922.*—Carabao, female. History of a previous attack in 1920 with maggots in the feet. Animal lame. All four feet affected. Foot maggots found in many of the puncture wounds. About one hundred taken from the four feet, the heaviest infestation in the hind feet.

Treatment.—Removed as many of the maggots as could be found and applied a chloroform pack to each foot for twenty-four hours. Eleven

[1] Antea, p. 141.

dead maggots found when pack was removed. Tar and sulphur ointment applied daily for three weeks. Skin wounds healed by that time, and the horn of the wall grown so that the holes that had been at the top were no longer in soft tissue. No more maggots being found treatment was discontinued and the animal kept under observation. Thirteen days later seventeen larvæ were found, one in each of the front legs and the rest in the hind legs. Same treatment as given before was given for two weeks and the case discharged as cured. A month later the animal was brought back to the clinic, having become reinfested. As the animal could not be left in the clinic, the maggots were removed and the caretaker was given a supply of tar ointment to apply daily.

2. Case 121, March 12, 1922.—Hereford, male. In hospital for myiasis of the external ear. Was kept in the same paddock with case 109. On April 1, 1922, the animal was observed to be lame in the left hind leg. Foot maggots found in the affected limb. At the juncture of the skin and horn a large larva was found half buried in a very small puncture wound.

Treatment.—Chloroform pack twenty-four hours, and daily application of the tar ointment for eight days. Animal completely recovered.

3. Case 146, April 2, 1922.—Hereford, male. Brought to the clinic with a history of lameness. Foot maggots found in the left hind foot.

Treatment.—Same as for case 121. Discharged as cured on April 8, 1922.

4. Case 182, May 15, 1922.—Hereford, male. Animal brought to the clinic with an abscess in the right flank. The feet were examined and four foot maggots found in the right hind foot.

Treatment.—An ointment made up of sulphur, 1; oil of tar, 2; sodium bicarbonate, 1; and wool fat, 8, was applied daily. Foot lesions cured in six days.

5. Case 220, June 24, 1922.—Hereford, female. Foot maggots found in all four feet.

Treatment.—Maggots removed and the ointment used in case 182 applied daily for three days. No treatment given the next two days. On June 29 a few small maggots were found in each of the four feet. Ointment again applied daily until July 4. Case discharged as cured on July 7, 1922.

6. Case 225, June 29, 1922.—Carabao, female. While inspecting the carabaos of the College of Agriculture for traces of previous infestations with foot maggots, one of the milking herd was discovered to be very restless and was sent to the clinic for examination. Many foot maggots were found in both hind feet.

Treatment.—Same as for case 182. The following day six small maggots were taken from the left hind foot, eight from the right hind foot, and one from the right front foot. Treatment continued, and no more maggots found. Case discharged July 4, 1922. Caretaker supplied with the ointment with instructions to apply daily. No reinfestation occurred.

7. Case 250, July 11, 1922.—Hereford, male. Brought to the clinic with a scrotal wound infested with screw-worm larvæ. Feet examined, and foot maggots found. Many eggs of the foot-maggot fly found attached to the hairs about the fetlock.

Treatment.—All maggots found were removed, and the hair was clipped short from the pasterns and fetlocks. Ointment as used for case 182

applied. Several dead larvæ removed the following day. Ointment then applied daily until July 18, when treatment was discontinued. Animal remained in the clinic until August 10, under observation, no recurrence of the condition taking place.

8. Case 251, July 11, 1922.—Hereford, male. History of lameness in the right hind leg, and larvæ in the foot. Had previously received treatment, consisting of chloroform pack and bandage. Two foot maggots found in the affected limb.

Treatment.—Same as for case 182. Discharged on July 13.

9. Case 252, July 11, 1922.—Hereford, male. History of lameness in left hind leg. A deep wound found ventral to the lateral claw of affected leg; also numerous puncture wounds at coronary band and at margins of claws of all four feet. More than one hundred foot maggots removed.

Treatment.—From the fetlock down the hair was cut short to remove fly eggs. Same ointment applied daily as in case 182. On the 16th a heavy application of pix liquidæ applied. No further treatment given. Animal under observation until August 1, with no reinfestation.

10. Case 259, July 13, 1922.—Hereford, male. History of lameness. Approximately eighty foot maggots and one screw-worm fly larva found.

Treatment.—Same as given to case 182. Discharged with feet in good condition on July 18.

11. Case 260, July 14, 1922.—Hereford, male. Brought to clinic with a wound in the prepuce infested with screw-worm larvæ. Feet found to be infested with foot maggots. Small puncture wounds present in the following numbers and locations:

48 in coronary band, right hind foot, of which 27 were at bulbs of heels.
19 around lateral dew claw, right hind foot.
18 around medial dew claw, right hind foot.
57 in coronary band, left hind foot, of which 43 were at bulbs of heels.
22 around lateral dew claw, left hind foot.
21 around medial dew claw, left hind foot.
29 in coronary band, right front foot.
19 in coronary band, left front foot.

Treatment.—Maggots removed, hair closely clipped, and a heavy coating of pix liquidæ applied. Three days later the application was repeated. No further treatment. Animal under observation until August 5. No reinfestation.

12. Case 298, July 24, 1922.—Goat, male. Sent to clinic for castration. Animal lame in right front leg. One large foot maggot found burrowing into tissue at the lateral surface of the carpus. Foot maggots also found at the coronary band of the feet in the following numbers:

3 in left front foot.
2 in right front foot.
5 in left hind foot.
3 in right hind foot.

Treatment.—Same as for case 121. Foot lesions cured July 31, 1922.

13. Case 299, July 24, 1922.—Goat, male. Sent to clinic for castration. Twelve foot maggots found in feet. All four feet affected.

Treatment.—Same as for case 121. Foot lesions cured in eight days.

14. Case 302, July 24, 1922.—Hereford, male. Sent to clinic with *Otitis externus.* Fourteen foot maggots found; all four feet affected.

Treatment.—Same as for case 260. Foot lesions healed in seven days. Still under observation.

15. Case 318, July 26, 1922.—Hereford, male. In clinic for an abscess in right costal region. Foot maggots in left hind foot.

Treatment.—Same as for case 121. Foot lesions cured August 7.

16. Case 319, July 26, 1922.—Goat, female. Animal weak, depressed. Left front foot gangrenous as high as carpus. Heavily infested with screw-worm larvæ. A few foot maggots present.

Treatment.—Leg amputated above the carpus. Animal died shortly after operation.

17. Case 321, July 26, 1922.—Goat, female. Large gangrenous wound at the fetlock, right hind leg. Foot maggots and screw-worm larvæ present.

Treatment.—Necrotic tissue removed and a chloroform pack applied. Following day, treated with a 10 per cent silver nitrate solution, and from then on received ordinary wound treatment. Discharged as cured August 23.

18. Case 322, July 28, 1922.—Hereford, male. History of lameness. All four feet found infested with foot maggots:

4 at coronary band, left hind foot.
5 at lateral dew claw, right hind foot.
7 at bulbs of heels, right front foot.
2 at bulbs of heels, left front foot.

Treatment.—Chloroform pack, painted with pix liquidæ every third day until discharged as cured August 3.

19. Case 324, July 28, 1922.—Hereford, male. All four feet infested with foot maggots.

Treatment.—Maggots removed and pix liquidæ applied every other day until discharged as cured on August 3.

20. Case 361, August 10, 1922.—Goat, female. Large gangrenous wounds at fetlocks of both hind feet. The right foot had been disarticulated at the fetlock by the maggots. Foot maggots and screw-worm larvæ present. Animal died before treatment could be given.

BOOPONUS INTONSUS ALDRICH

LIFE HISTORY

Egg.—Elongate ovoid, with the anterior end somewhat pointed. Dull grayish white. Attached to the hairs of the host by means of a membrane formed by a gelatinous secretion of the female at the time of oviposition. Somewhat flattened on the side of attachment, the anterior or more-pointed end placed toward the base and closely applied to the hair. Smooth except for a band of small punctures on the outer or dorsal surface on the median line. Average measurements: Length, 0.875 millimeter; breadth, 0.229 (Plate 2, figs. 5 and 6).

Young larva.—The young larva resembles the full-grown larva, but differs in that the body spines are much darker and there are but two slits in each of the posterior stigmata (Plate 4, fig. 1).

Full-grown larva.—Body plump, robust, cylindrical; wedge-shaped when fully extended (Plate 1, figs. 1 and 4). Posterior

end rounded and invaginated, with one very small pair of tubercles dorsad, another pair ventrad, and a third pair lateroventrad of the stigmata (Plate 1, fig. 7). Body grayish white, lateral fusiform areas absent, ventral areas present. Body surface covered with irregular rows of short, stout, reclinate, pale brown spines (Plate 1, fig. 6). Head retracted into thorax when at rest, bilobed, with a pair of minute, sometimes faintly pigmented papillæ anteriorly and a brown chitinous comb ventrobasally on each lobe (Plate 1, fig. 8; Plate 3, fig. 1). Oral hooks two, toothed, dark brown to black, and recurved ventrally (Plate 2, fig. 2). Amphipneustic. Anterior spiracular projections swollen, with tubercular surface, trachea (visible through the projections) with 18-digitate extremities (Plate 1, fig. 5; Plate 3, fig. 1). Posterior stigmal plates on swollen hemispherical areas on the sides of the invaginated region of the posterior end of the last abdominal segment (Plate 1, fig. 7). Slits three, subparallel, with serrate edges (Plate 1, figs. 2 and 3; Plate 4, fig. 2). Length, 8.5 to 10 millimeters; breadth, 2.5 to 3.

Puparium.—Regularly ellipsoidal, rich chestnut brown to black (Plate 2, fig. 3). Surface finely rugose, with very short recumbent spines except for small bare areas along the segmental sutures which serve to accentuate the segmentation. Anterior spiracular projections protruding and tuberculous (Plate 2, fig. 4); posterior stigmal plates slightly swollen, black, with the same general appearance of the anal stigmata of the full-grown larva. Size variable, average length, 6 to 7 millimeters; breadth, 2.25 to 2.75.

Adult.—For description of the adult stage,[2] the reader is referred to the original description of Aldrich (antea, p. 141).

HABITS

Oviposition.—Occasionally the adults may be seen hovering around the legs of carabaos and bullocks. They alight on the lower portions of the leg and deposit their eggs on the hairs of the host. A gelatinous material secreted by the female at the time of oviposition serves to attach the egg to the hair (Plate 2, fig. 6). Almost invariably the eggs are placed head downward. As many as four eggs on one hair have been noted. More commonly only one egg is found on a single hair, and it is usually

[2] It is interesting to note that although some forty adults have been reared from the several different cases, only females have so far been obtained.

placed at about the middle. Eggs are deposited on the lower portions of the legs, principally between the toes and at the heel under the dew claws, less commonly up as high as the knee.

Hatching.—The young larva emerges from the egg by cutting a small circular flap on the dorsal surface of the anterior end of the egg (Plate 2, fig. 5). The incubation period varies considerably, possibly dependent upon certain stimuli which the egg may receive under conditions favorable for the young larva to become established in the host. Under laboratory conditions eggs hatched in from three to five days.

Young larva.—The young larvæ emerge from the egg headed toward the base of the hair. They work their way down the hair and then down the leg to the coronary band. Whether they attempt to enter the flesh at places other than that of the region of the coronary band is not known, but the presumption is that such is the case. In two cases, foot maggots have been found infesting regions other than that of the coronary band. Both of these were goats, animals whose skin is comparatively thin and tender. In these animals, both the coronary region and the knee were infested. In all other cases only the coronary region was involved. In all of the host animals, the tenderest part of the leg is the bulb of the heel, and the heaviest infestations are always found there. From these facts and from observations on newly hatched larvæ it seems safe to say that the larvæ attempt to enter the flesh at the point at which they happen to be when hatched, or they wander around searching until they find a place to enter or are brushed off or die. Because of the softness of the tissue of the coronary region, especially around the heel, the larvæ that survive and reach that region are able to enter and bury themselves in the flesh. Evidently the young larvæ enter the flesh before the third pair of slits is formed on the posterior stigmal plates, for no specimens with three pairs have been observed outside the tissue of the foot, and many that have but two pairs have been dug out of the flesh.

The maggots bury themselves in the tissue nearly parallel to the surface, leaving their posterior end exposed. The entrance holes are simple and small (Plate 7, figs. 1, 3, and 4), and once in the flesh the larvæ do not move around to any appreciable extent.

Full-grown larva.—The length of the larval period is not definitely known. From case histories and reinfestations, it appears that the period probably ranges from two to three weeks.

The full-grown larvæ leave the flesh and drop to the ground, where they bury themselves and pupate. The great variation in size of pupæ seems to be a direct result of the amount of available larval food. The pupal period is approximately ten days. The imago escapes from the pupa case by splitting the operculum, or cap, on the median line, and pushing the two halves aside as flaps.

OCCURRENCE AND ABUNDANCE

Adult.—The adult flies have not previously been observed. The genus and species were described from specimens reared from infested animals on the campus of the College of Agriculture at Los Baños, Laguna Province. Since the first breeding was made, a few adults have been observed depositing eggs on the feet of a carabao kept at the Forest School at Los Baños. No further records of its occurrence or abundance are extant, nor were specimens of the fly present in the collections of the College of Agriculture, the Bureau of Science, or the private collection of Prof. C. F. Baker, previous to its discovery. From the fact that the region around Los Baños is perhaps better known entomologically than any other in the Islands, it would appear that the fly is comparatively rare. Cases of myiasis produced by the maggots, however, tend to show that such is by no means the case.

Larva.—Twenty cases of myiasis caused by this fly subsequent to its recognition, have been recorded in the clinic of the College of Veterinary Science at Los Baños. Previous to that time there were undoubtedly other cases, but they were probably confused with myiasis produced by the screw worm, *Compsomyia dux* Eschscholtz, a very common and harmful pest of stock in the Philippines. The effects of infestations of the foot maggot are quite definite and distinctive. From these effects it has been possible to gather some data on the relative abundance of infestations. The college herds were examined, with the results indicated in Table 1.

TABLE 1.—*Showing incidence of foot-maggot infestations in the animals of the College of Agriculture.*

Hosts.	Positive.	Negative.
Work bullocks and Nellores	3	14
Milk animals (carabaos)	3	3
Carabaos	9	4
Herefords	12	3

Veterinary students reported the prevalence of the disease in the various barrios of Los Baños as shown in Table 2.

TABLE 2.—*Showing incidence of foot maggots among animals in Anos, Malaquing Bato, Maahas, and San Antonio Barrios.*

Hosts.	Positive.	Negative.	Attacked.
			P. ct.
Carabaos	13	11	54
Native cattle	5	36	12
Goats	0	8	0
Total	18	55	25

All of the Filipino farmers in different parts of Laguna Province, to whom foot-maggot cases or the characteristic after effects were shown, have stated that the condition is a rather common one and that often animals are laid up from lameness due to maggots, *uod*, in the feet.[3] From their descriptions of the infestations and from the fact that they recognized the hoof injuries resulting from such infestations, it is presumed that the cases at the College of Agriculture cannot be considered either unique or endemic. A further fact, brought out in conversations with owners of stock in Laguna Province, was that the number of cases was greatest in the dry season, and this checked with observations made by us on the college herds. This seasonal occurrence may be explained by the fact that during the wet season the animals spend a greater part of their time in mud and water. The mechanical action of the mud would tend to remove the larvæ and, perhaps, the eggs. The flies would also have greater difficulty in depositing the eggs. Actually, eggs are much more difficult to obtain in the rainy season. Further, Hereford cattle are much more susceptible to the attacks of the fly than are carabaos. Carabaos will wallow in mud at every opportunity, while Herefords are essentially dry-pasture animals. Still further evidence is offered in the case of the carabao owned by the Forest School of the Bureau of Forestry. This animal has had a continuous series of infestations throughout the dry season. No animal in the college herd has had a comparable amount of trouble from this pest. The Forest School carabao, however, never wallows in the mud, there being no facilities for this at the Forest School, while the college animals are pastured

[3] We are informed through Dr. Miguel Manresa, of the College of Veterinary Science, that there is a local word, *kayuko*, which refers to this particular myiasis. The use of the term appears to be quite local.

in fields with plenty of wallows and the animals can soak themselves at will.

HOST ANIMALS

So far only Bovidæ have been recorded as hosts. Maggot specimens have been obtained from Hereford, Nellore, and Philippine cattle, carabaos, and goats. Data available are not sufficient to allow the drawing of definite conclusions relative to the susceptibility of the various kinds of animals. However, in the vicinity of Los Baños the order of percentage of attack observed is: Hereford cattle, carabao, Philippine and Nellore cattle, goats.

DIFFERENTIATION BETWEEN SCREW WORMS AND FOOT MAGGOTS

The common screw worm of the Philippines, *Compsomyia dux*, differs from the foot maggot in several very obvious details. Because the former is the maggot most likely to be confused with the foot maggot, descriptions of the larval and pupal stages are included in this paper.

COMPSOMYIA DUX ESCHSCHOLTZ

Larva.—Body elongate, regularly tapering and wedge-shaped. Posterior end truncate. Body yellowish white. Anterior margin of each segment swollen and with several irregular rows of short, stout, reclinate spines. Head bilobed, with a pair of blunt tubercles, one above the other, on each lobe (Plate 3, fig. 2). Oral hooks two, toothed, dark brown, and strongly recurved ventrally (Plate 2, fig. 1). Segments 5 to 10 with lateral, spinulose, fusiform areas against the anterior margin of the following segment. Segments 6 to 11 with narrow, transverse, smooth, fusiform areas on the somewhat broadened ventral part of the swollen spinulose anterior rings. Amphipneustic. Anterior spiracles probably not functional, indistinct, consisting of a row of six small circular openings. Posterior stigmal plates approximate, situated at the bottom of a deep cavity at the posterior tip of the body. Slits three, subparallel, without button, and chitinous process not completely inclosing them. Ten small tubercles on the edge of the stigmal cavity (Plate 5). Segment 12 with a swollen spinulose area ventrally which is bisected transversely by a smooth area and gives rise to two, large, widely separated tubercles. Length, 12 to 12.5 millimeters; breadth, 3.5 to 4.

Puparium.—Regularly ellipsoidal, chestnut brown to black. Surface finely rugose, with recumbent spines located as in larva. Anterior spiracles not apparent. Posterior stigmal plates not sunken, but otherwise as in larva. Size variable. Average length, 10 millimeters; breadth, 3.

Distinguishing characters.—Screw-worm infestations are usually secondary. The adults are attracted to open wounds and blood, and the larvæ enter the flesh through the broken skin. In a few cases, crushed engorged ticks or drops of blood from tick bites or horsefly bites are the attraction for the screw-worm fly, and myiasis may occur at those points without previous abrasion. Screw worms are often found in feet previously injured by foot maggots. Foot maggots, on the other hand, usually occur as primary pests.

Screw-worm infestations may occur on any part of the body, while foot maggots are apparently confined to the coronary region of the tougher-skinned animals, and have been found as high up the leg as the knee in the tenderer-skinned animals, such as goats. Again, foot maggots appear to be confined to the Artiodactyla, while screw worms attack all mammals.

The larvæ may be easily distinguished by the characters noted in Table 3.

TABLE 3.—*Showing distinguishing larval characters of the screw worm and the foot maggot.*

Character.	Screw worm.	Foot maggot.
Shape	Cylindrical, wedged-shaped when at rest.	Plump, robust, more or less ellipsoidal when at rest.
Surface	Each segment with but a few irregular rows of spines on the anterior half.	Entire surface of each segment with irregular rows of spines.
Posterior spiracles	With a heavy chitinous ing around the slits. Stigmal plates approximate.	Without heavy chitinous ring. Stigmal plates separate.
Anterior spiracles	Indistinct, with six openings.	Conspicuous, with eighteen openings.
Color	Yellow-white.	Grayish white.
Posterior stigmal invagination	Surrounded with ten tubercles.	Surrounded with six tubercles.

SUMMARY

The eggs of the foot maggot are laid on the hairs of the lower extremities of the legs of the host animals. The larvæ work their way down to the skin and attempt to enter the flesh. In the tougher-skinned animals, they are unable to enter at any

place other than the coronary region of the foot. The increase from two to three slits in the posterior stigmal plates of the larva takes place while the larva is buried in the flesh. The injury by the foot maggot is primary, but is often followed by serious secondary infestations or complications. The fully developed larvæ leave the foot and enter the soil for pupation.

Cases of foot-maggot myiasis and observations on animals tend to show that the fly is neither rare nor local. In the past it has evidently been confused with the screw worm. Circumstantial evidence shows that the habits of the host animals have a direct relation to their susceptibility. Seasonal occurrence of the insect is dependent, to some extent, upon the same factors that control its relative abundance on its various hosts.

The host animals appear to be confined to the Bovidæ, or at least to the Artiodactyla. So far only Bovidæ have been definitely proven as hosts.

Symptoms.—A lameness, that varies in degree, is usually the first indication of foot-maggot infestation. The animal is restless and shakes the affected limb. It is often observed raising the leg and licking the infested area. If all four feet are involved the animal will assume a recumbent position at every opportunity.

Numerous small puncture wounds are found in the skin at the coronary band, and in the soft horn at the dorsal border of the horn wall of the large claws. The bulbs of the heels are usually the most heavily infested (Plate 7, figs. 1, 3, and 4). Wounds of the same type are also found at the margins of the small claws. When the larvæ are numerous, the area affected exhibits a honeycomb appearance. These wounds are superficial, and do not extend into the underlying structures. However, they offer an entrance for infection and secondary infestation with screw-worm larvæ (Plate 7, fig. 2). Infection is practically always present in cases of long standing, and then the amount of tissue destruction assumes serious proportions.

As a sequel to the destruction of the coronary band and of the soft horn, many small transverse cracks and crevices are found in the horn wall extending as low as the ground border (Plate 8, figs. 1, 2, 3, 4, and 5). The transverse rings are also distorted.

Prognosis.—Favorable, providing treatment is given early to prevent complications.

RECOMMENDATIONS

Treatment.—From the results observed in the treatment of clinic cases and from the knowledge of the habits of the fly itself, the following treatment is considered most efficient. Clean the affected area with soap and water. To get rid of the fly eggs, closely clip the hair from around the feet. Remove as many of the maggots as possible and apply a chloroform pack for twenty-four hours. This should be followed by heavy applications of pix liquidæ every third day until the lesions heal. The chloroform pack can be dispensed with provided the infestation is of so recent occurrence that the pix liquidæ can be applied directly to the maggots.

Prevention and after treatment.—All cattle, carabaos, and, possibly, goats should be inspected daily, especially during the dry season, to prevent this type of myiasis from spreading throughout the herd, and also to start early treatment of the affected animals. Inspection is not difficult as the condition is easily recognizable. During the dry season it is important that the animals have access to plenty of water, as the mud on their legs makes it difficult for the fly to attach its eggs.

ILLUSTRATIONS

PLATE 8

FIG. 1. Anterior view of left fore foot of carabao, showing foot-maggot injury.

2. Anterior view of left hind foot of carabao, showing foot-maggot injury.

3. Posterior view of left hind foot of carabao, showing foot-maggot injury to dew claws.

4. Lateral view of left fore foot of carabao, showing foot-maggot injury.

5. Lateral view of right hind foot of carabao, showing foot-maggot injury.

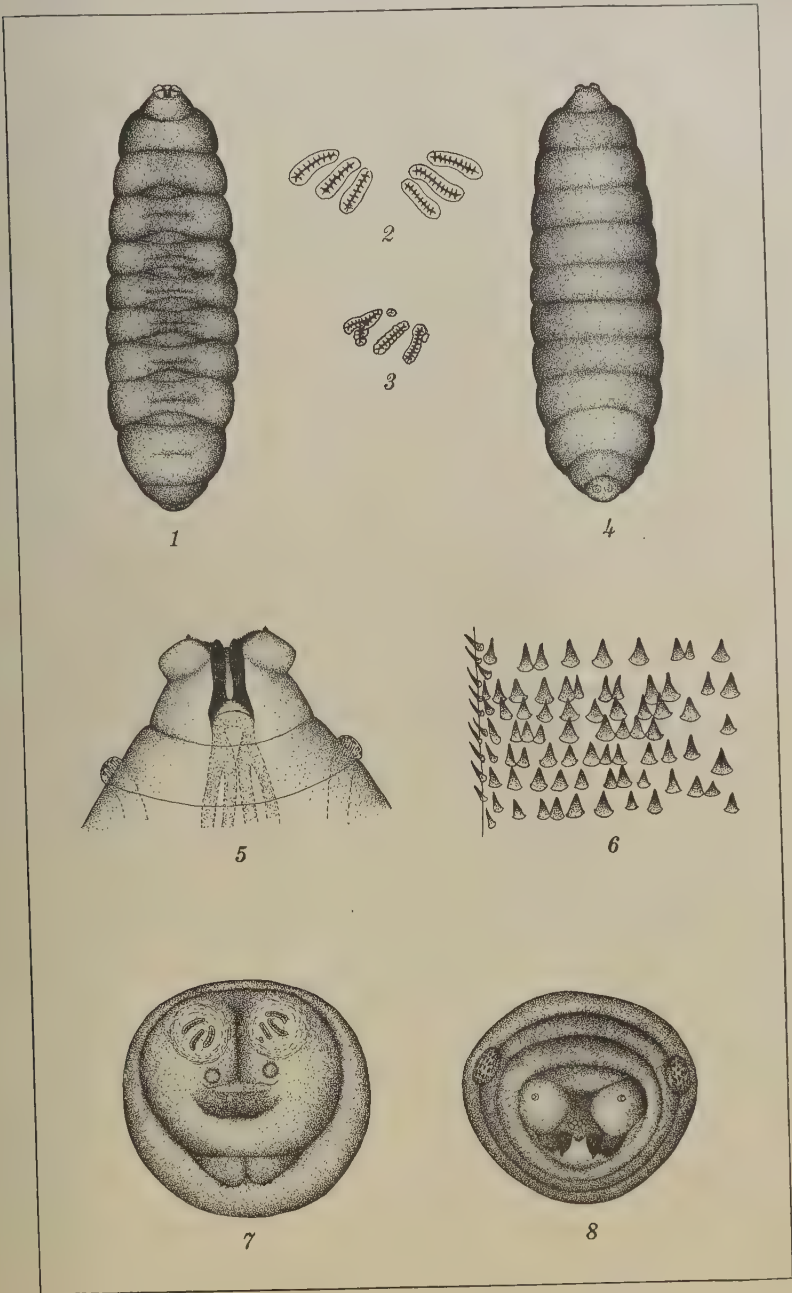

PLATE 1.

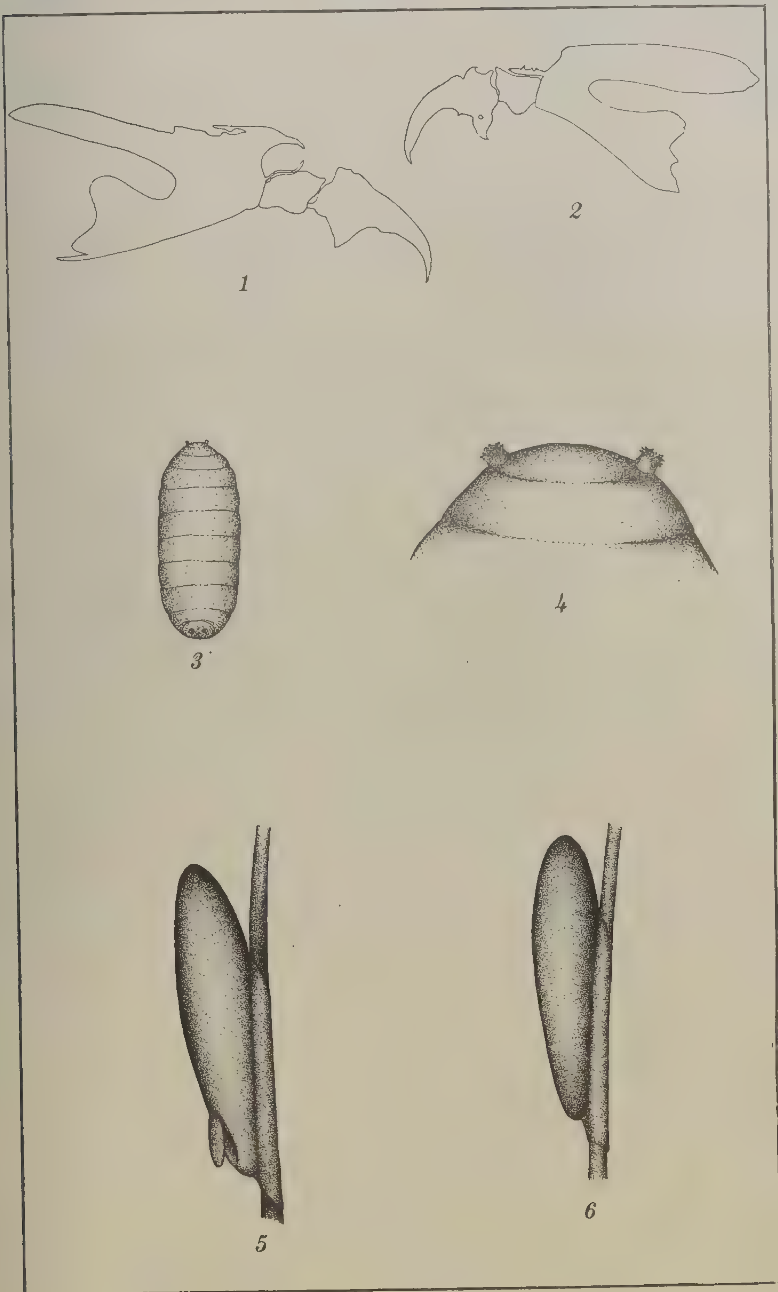

PLATE 2.

1

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PLATE 3.

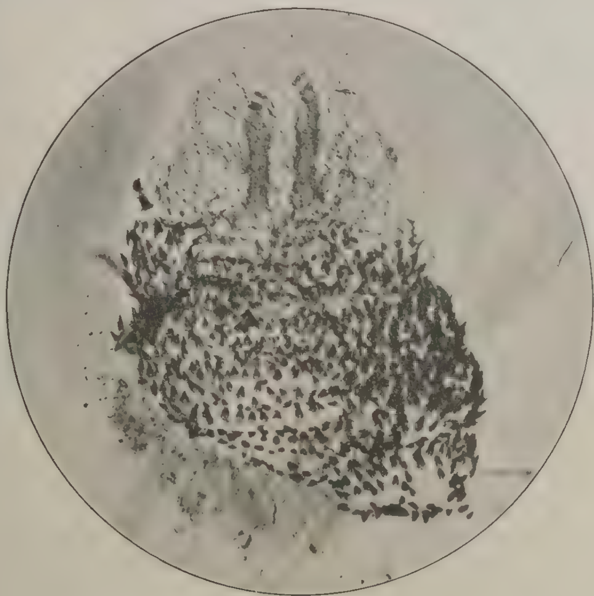

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PLATE 4.

PLATE 5.

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PLATE 6.

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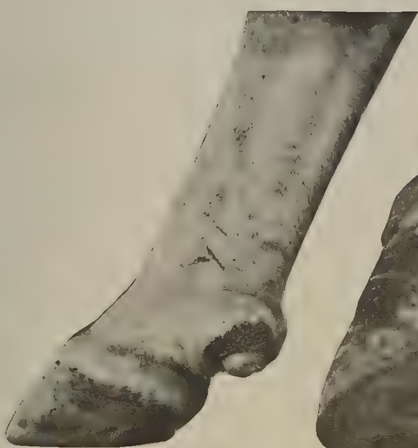

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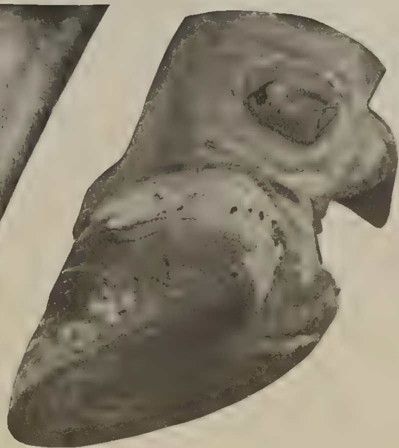

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PLATE 7.

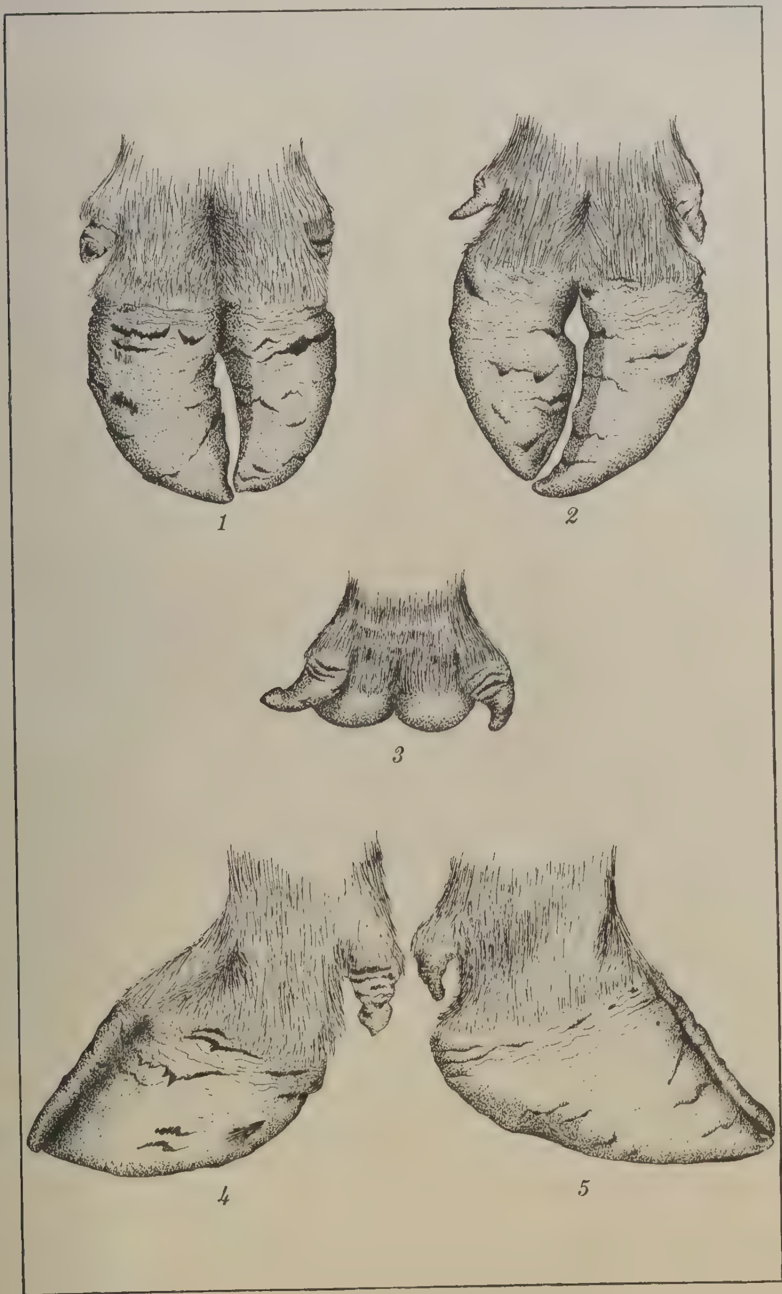

PLATE 8.

A NEW PHILIPPINE STENOCRANUS (DELPHACIDÆ, HOMOPTERA)

By F. Muir

Of the Hawaiian Sugar Planters' Experiment Station, Honolulu

TWO TEXT FIGURES

Stenocranus seminigrifrons sp. nov. Fig. 2.

Male.—Macropterous; length, 2.7 millimeters; tegmen, 3.3. Length of vertex, pronotum, and mesonotum 1.6 times the width of head including eyes; length of vertex 1.5 times the width at base, base slightly broader than apex; length of face 2.2 times the width, sides straight, slightly diverging apically, apex

Fig. 1. *Stenocranus nigrifrons* Muir; male genitalia, right lateral view.

Fig. 2. *Stenocranus seminigrifrons* sp. nov.; male genitalia, right lateral view.

broader than base. Antennæ reaching slightly beyond base of clypeus, first segment longer than broad, second segment 1.6 times the length of first. Lateral pronotal carinæ straight, diverging, not quite reaching hind margin. Hind basitarsus slightly longer than the other two together, spur about as long as basitarsus, thin, with many small teeth on margin.

The genitalia of this species differ from those of *S. nigrifrons* Muir in having the anal spines much larger and diverging, with a small spine toward the apex; the ædeagus is curved about one-third from apex into a crook, forming nearly a semicircle, and the genital styles are longer and slender. The two species are closely related.

Ochraceous yellow; fuscous over vertex and base of frons; clypeus dark brown between the lateral carinæ. Tegmina hyaline, slightly ochraceous, slightly fuscous over cubital area.

Female.—Macropterous; length, 3.2 millimeters; tegmen, 3.5. The female I associate with this has the clypeus and the whole of the frons between carinæ dark brown; it also has a lighter mark down dorsum.

Described from one male from Baguio, Benguet Province, Luzon, and one female from Dapitan, Mindanao. There is also a female from Tangkulan, Bukidnon Province, Mindanao (*16785*) and one from Kolambugan, Mindanao (*16784*) which may be of the same species (coll. *Baker*).

This species, as well as *S. nigrifrons*, is not typical of the genus. The first segment of the antennæ is distinctly longer than wide, and the junction of vertex and face in lateral view is parallel with eyes and not produced far enough; but for the present it would better stand in *Stenocranus*.

Nilaparvata bakeri (Muir).

Delphacodes bakeri MUIR, Proc. Haw. Ent. Soc. III 4 (1917) 336, pl. 6, fig. 47.

This species is now known from Formosa.

ILLUSTRATIONS

TEXT FIGURES

THE GENUS MYNDUS IN THE MALAY ISLANDS (HOMOPTERA)

By F. Muir

Of the Hawaiian Sugar Planters' Experiment Station, Honolulu

ONE PLATE

Genus **MYNDUS** Stål

Myndus Stål, Berl. Ent. Zeit. 6 (1862) 307; type, *musivus* Stål.

Most of the described species of this genus inhabit North America and the West Indies, thirteen species being recorded from those regions. Two species are recorded from the Palæarctic Region, one from Fiji, and one from Samoa. The present paper describes eleven species from the Malay Islands and thereby gives a totally different orientation to the distribution of this genus. These species differ from the type species in having the vertex and frons comparatively broader, especially *Myndus caligineus*. In this respect they approach such North American species as *M. erotatus* Van Duzee, but in this species the transverse carina is indistinct and there is an indistinct longitudinal median carina on the basal half of the vertex.

The first five are all closely related; *M. semialbus* stands by itself as does *M. dolosus; M. fasciatus* and *M. brunneus* from Amboina are also isolated. The two species from Borneo, *M. mundus* and *M. caligineus*, differ considerably from the others. Many more species of this genus are sure to be found in the Malay Archipelago, but their identification will be almost impossible unless the male genitalia are described or figured.

The types of the new species described in this paper are in the Hawaiian Sugar Planters' Experiment Station collection, Honolulu. Paratypes, when present, are in the Baker collection.

Myndus maculosus sp. nov. Plate 1, fig. 1.

Male.—Length, 2.1 millimeters; tegmen, 2.9. Width of vertex at base slightly greater than length in middle; transverse carina about middle. Length of face subequal to width, narrowest at base. Forking of Sc and R slightly basad of Cu.

Pygofer asymmetrical; right side produced into a large process rounded at apex, left side with a small projection near anal angle; medioventral process subconical in outline. Anal segment asymmetrical, the left margin being much lower than the right. Genital styles small, flat laterally, bent in middle to nearly a right angle, apex bluntly pointed. Periandrium with apical two-thirds membranous, basal third chitinous, a large process on ventral aspect bifurcate at apex, one very small and the other larger and curved, two small spines on the right side; ædeagus membranous.

Stramineous; darker over abdomen. Tegmina hyaline, apices of apical veins fuscous extending a little way down, apical crossveins fuscous, a few small spots at crossveins, one at apex of costa, one at fork of Sc and R, one at fork of Cu, one at apex of clavus, one at fork of clavus; veins stramineous except at spots, tubercles minute, same color as veins. Wings hyaline, veins slightly stramineous.

Female.—Length, 2.2 millimeters; tegmen, 3. In color a little darker than male, especially over the abdomen.

LUZON, Laguna Province, Los Baños (*Muir*), September, 1915, 2 males and 8 females; (*Baker 1304*), 1 female: Tayabas Province, Malinao (*Baker*), 1 female. Type No. 1069.

Myndus mindanaoensis sp. nov. Plate 1, fig. 2.

Male.—Length, 2 millimeters; tegmen, 2.8. In build and coloration this species is very similar to *M. maculosus*, but the genitalia differ as follows:

Right lateral margin of anal segment produced into two pointed processes; the production on right margin of pygofer longer and narrower at base, the angular projection on left side larger; genital styles larger with three small lobes at apex; the basal portion of periandrium having one bilobed process with lobes short, pointed, curved, and of equal length.

Female.—Length, 2.7 millimeters; tegmen, 3. Similar to *M. maculosus*, but slightly darker and the spots on tegmina darker.

MINDANAO, Kolambugan (*Baker*), 1 male: Dapitan (*Baker*), 2 females. Type No. 1070.

Myndus palawanensis sp. nov. Plate 1, fig. 3.

Male.—Length, 2.3 millimeters; tegmen, 2.7. Vertex slightly longer than width at base, base considerably wider than apex; frons slightly longer than wide, narrowest at base. Sc + R forking about middle of costa, Cu forking slightly more distad.

Pygofer asymmetrical, right side produced into a long quadrate process about two and one-half times as long as broad; left side produced into a small angle at anal angle, medioventral process angular. Anal segment large and asymmetrical, the shape as shown in figure. Periandrium with a thick process from near base with its apex bifurcate, a smaller spine nearer the apex. Genital styles flat, narrow, angular in middle.

Light brown. Tegmina hyaline, slightly stramineous, veins slightly darker; tubercles very small, same color as veins; apices of apical veins fuscous, crossveins, a dot at apex of clavus and at apex of costal and at fork of cubitus fuscous. These fuscous spots are very faint in some specimens; and in some there is a faint suggestion of a fuscous mark from middle of costa to apex of clavus.

Female.—Length, 3 millimeters; tegmen, 3.7. Considerably darker in color than the male, marks on tegmina more distinct.

PALAWAN, Puerto Princesa (*Baker 10071*), 3 males and 2 females, type locality. MINDANAO, Dapitan (*Baker 13347, 13348*), 1 male and 2 females; Butuan (*Baker 10073*), 1 female. BASILAN (*Baker*), 3 specimens. BORNEO, Sandakan (*Baker 13343*), 2 males and 2 females. Type No. 1067. There are also three females from Larat (*F. Muir*), December, 1907, and one from Piroe, Ceram (*Muir*), January, 1909, which agree with the Philippine females, but I have not included them in the type material.

Myndus hyalinus sp. nov. Plate 1, fig. 4.

Male.—Length, 2.5 millimeters; tegmen, 3. Width of vertex slightly greater than length in middle, transverse carina about middle, base considerably wider than apex; width of frons nearly equal to length, narrowest at base; median ocellus present. Sc + R forked about middle of costa, Cu forked slightly distad.

Pygofer asymmetrical, the right side produced into a large quadrate process, longer than broad, with the dorsal corner forming a minute point; medioventral margin produced into a conical outlined process. Anal segment large, asymmetrical, as shown in figure. Periandrium with five spines, a large, curved basal one, two smaller slightly distad, and two very small ones near apex. Genital styles bent nearly at a right angle in middle.

Frons, vertex, and mesonotum dark brown; pronotum, legs, and abdomen lighter brown. Tegmina hyaline, slightly stramineous, veins stramineous, tubercles very small, same color as veins. Wings hyaline with light brown veins.

Female.—Length, 3 millimeters; tegmen, 3.3. Same color as male. Ovipositor considerably longer than pygofer, projecting well beyond apex of anal segment; pygofer longer than wide.

MINDANAO, Butuan (*Baker 10074*), 2 males and 2 females: Iligan (*Baker 10072*), 1 female. Type No. 1066.

Myndus obscuratus sp. nov. Plate 1, fig. 5.

Male.—Length, 3 millimeters; tegmen, 3.8. Length of vertex in middle equal to width at base; transverse carina about middle; face about as wide as long. Forking of Sc and R about middle of costa, Cu forking slightly more distad.

Pygofer asymmetrical, the right side being produced into a large process, medioventral process angular. Anal segment asymmetrical, in lateral view the left side of the ventral margin produced into a large angular process slightly curved, the dorsal margin into a large angular process, the apex pointed, the right side not so produced. The genital styles curved, with a large rounded process in the middle of the inner margin, apex slightly rounded. Periandrium fairly large with seven or eight spines as in figure.

Stramineous; slightly darker over vertex and middle of mesonotum. Tegmina hyaline, very slightly stramineous; veins stramineous, slightly fuscous on apices; tubercles numerous, minute; a faint fuscous mark at apex of clavus. Wings hyaline, veins light brown.

Female.—Length, 3.4 millimeters; tegmen, 4. Similar to male but darker over thorax and abdomen; ovipositor projecting beyond the pygofer, pygofer longer than wide.

LUZON, Mount Banahao (type locality) and Mount Maquiling (*Muir*), February, 1914; (*Baker 2824, 2883, 10071*), 5 males and 3 females. Type No. 1068.

Myndus semialbus sp. nov. Plate 1, fig. 6.

Male.—Length, 2 millimeters; tegmen, 2.5. Length of vertex in middle very slightly less than width at base, apex slightly narrower than base; transverse carina in middle, distinct. Length of face equal to width, narrowest at base, widest before apex, frontal ocellus distinct. Forking of Sc and R about one-third from base, M leaving Sc + R near base, Cu forking slightly before apex of clavus, M with five apical veins.

Pygofer symmetrical, medioventral margin produced into a process subconical in outline, lateral angles produced into a rounded process which is produced into a spine on the lower portion. Anal segment large, asymmetrical, the ventral margin

produced and ending in two unequal spines. Genital styles small, flat, curved, apex truncate. Periandrium short, the basal portion produced into a large spine and the apical margin into a small spine, penis membranous.

Dark brown; legs, pygofer, and anal segment lighter. Tegmina hyaline, basal portion to nodal line brown with a light band through the middle, apical half hyaline with a waxy covering making it white. Veins same color as membrane, tubercles small, numerous, bearing light macrotrichia. Wings hyaline with brown veins.

Female.—Length, 2.2 millimeters; tegmen, 2.7. Color similar to that of male. Pygofer longer than wide, ovipositor complete, a little longer than pygofer.

LUZON, Mount Banahao and Mount Maquiling (*Muir*), September, 1915; (*Baker*), 4 males and 3 females. Type No. 1064.

Myndus dolosus sp. nov. Plate 1, fig. 7.

Male.—Length, 2.6 millimeters; tegmen, 3. In general build and markings this species is similar to *M. maculosus*, but the genitalia differ. In lateral view the anal segment beyond anus is not produced into an angle but is rounded, the apex is rounded asymmetrically; the right margin of pygofer is angularly produced; the left margin slightly sinuous but not produced; genital styles not so angularly bent in middle; the ædeagus is small, the apical portion of the periandrium and the penis are membranous, the basal portion of periandrium is produced into two similar, flat, curved spines with a couple of minute spines between them on ventral aspect.

Straits Settlements, Penang Island (*Baker 10077*), 3 males. Type No. 1071.

Myndus fasciatus sp. nov. Plate 1, fig. 8.

Male.—Length, 2 millimeters; tegmen, 2.7. Length of vertex in middle equal to width at base, base shallowly emarginate, transverse carina about middle, obscure; face slightly longer than broad, median ocellus distinct. Cu forking slightly before apex of clavus, Sc + R before Cu, about one-third from base, M joining Sc + R near base, M with five apical veins.

Pygofer and anal segment asymmetrical; periandrium fairly long with three spines near apex. Genital styles flat, fairly narrow, angular, apex truncate with a minute spine on outer angle. The shape of genitalia is better shown in figures.

Light brown, mesothorax darker with lighter carinæ, legs light. Tegmina hyaline, a brown mark down middle of clavus,

broad at base and narrowing to apex, a brown band across from middle of costa to apex of clavus with two darker marks on costa, apex brown, two brown marks on costa before stigma, veins same color as membrane except in hyaline band across corium where there are some brown marks on the veins; tubercles minute, same color as veins.

Female.—Length, 2.6 millimeters; tegmen, 2.8. Body slightly darker in color. Ovipositor slightly longer than pygofer.

AMBOINA, March and April, 1908 (*Muir*), 1 male and 4 females. Type No. 1065.

Myndus brunneus sp. nov. Plate 1, fig. 9.

Male.—Length, 2.6 millimeters; tegmen, 2.9. Length of vertex along middle equal to width of base, base wider than apex, transverse carina in middle distinct, base roundly emarginate. Length of face equal to width, narrowest at base, gradually widening to near apex, then narrowing, sides rounded on apical half. Frontal ocellus distinct. Forking of Sc_2 and R_9 near middle; M leaving Sc and R at base; C forking about level with the fork of Sc and R; M with five apical veins, namely, 1, 1a, 2, 3, and 4; R with two apical veins. Claval veins joining commissure before apex of clavus.

Pygofer symmetrical, lateral margins entire; medioventral edge produced into a small angular process. Anal segment median size, asymmetrical, on the right side a spine arises from the margin and is directed basally, on the left side a longer spine is directed ventrally at right angle to anal segment. Ædeagus median size, the epiandrium flattened laterally with three large spines on the ventral aspect near apex, the two apical spines thin and curved, the more basal one broad at base and serrated on edge and drawn out into a fine point. Genital styles flattened laterally, angular about middle, apex broad and truncate, a flange or carina runs from near apex to ventral margin near base.

Brown; rostrum, legs, and hind margin of pronotum lighter. Tegmina brown, lighter in middle, veins slightly darker, tubercles small, bearing black macrotrichia. Wings fuscous, veins brown.

Female.—Length, 2.9 millimeters; tegmen, 3.4. In build and color similar to male. Ovipositor projecting beyond pygofer; anal segment a little longer than broad.

AMBOINA, January, 1908 (*Muir*), 1 male (holotype), 1 female (allotype), 1 damaged male. Type No. 1048.

Myndus mundus sp. nov. Plate 1, fig. 10.

Male.—Length, 2.7 millimeters; tegmen, 3. In build and color this species is very much like *M. hyalinus*, but it is slightly lighter in color and the genitalia are quite distinct.

Pygofer symmetrical, the medioventral process short and widely angular. Anal segment but slightly asymmetrical, apex rounded, left margin slightly lower than right. Periandrium fairly large, subangularly produced on dorsal aspect near apex, with two long, thin processes arising from a common base and forming a U-shaped process near the apical margin on right side, penis considerably chitinized with two long spines and a small one between them. Genital style nearly straight, slightly curved at apex where it is produced into a broad spine pointing basad. Apex round, inner margin entire, slightly convex at apex, outer margin slightly sinuous.

Female.—Length, 3 millimeters; tegmen, 3.7. Similar to the male; lighter in color than *M. hyalinus*.

BORNEO, Sandakan (*Baker*), 1 male and 1 female. Type No. 1072.

Myndus caligineus sp. nov. Plate 1, fig. 11.

Male.—Length, 2.4 millimeters; tegmen, 3. Width of vertex at base considerably (one-third) greater than length in middle; transverse carina distinct in middle; frons about as wide as long, slightly larger before apex, base and apex subequal in width; median ocellus distinct. Fork of Sc and R near base, fork of Cu about middle of clavus.

Pygofer symmetrical, medioventral process small, lateral margins entire, not produced. Anal segment symmetrical, much longer than broad, apex rounded, anus about middle. Periandrium long, tubular, with one large spine on ventral aspect near apex pointing basad; penis long, semichitinous with four spines, two about middle, the other two more apical. Genital style small, inner margin entire, slightly convex, outer margin straight on basal half, then concave, apex truncate.

Dark castaneous, legs slightly lighter. Tegmina dark castaneous, tubercles small, numerous, dark; wings castaneous, veins darker.

Female.—Length, 2.8 millimeters; tegmen, 3.3. In coloration similar to male.

WEST BORNEO, Mowong, September, 1907 (*Muir*), 1 male and 1 female. Type No. 1073.

ILLUSTRATION

PLATE 1

FIG. 1. *Myndus maculosus* sp. nov.; *a*, male genitalia with ædeagus dissected out, left lateral view; *b*, ædeagus, left lateral view.

2. *Myndus mindanaoensis* sp. nov.; *a*, male genitalia with ædeagus dissected out, left lateral view; *b*, ædeagus, left lateral view.

3. *Myndus palawanensis* sp. nov.; *a*, genitalia with ædeagus dissected out, left lateral view; *b*, ædeagus, left lateral view.

4. *Myndus hyalinus* sp. nov.; *a*, pygofer and anal segment, right lateral view; *b*, ædeagus and left style, left lateral view; *c*, anal segment, end view.

5. *Myndus obscuratus* sp. nov.; *a*, male genitalia with ædeagus dissected out, lateral view; *b*, ædeagus, left lateral view.

6. *Myndus semialbus* sp. nov.; *a*, male genitalia with ædeagus dissected out, left lateral view; *b*, ædeagus, left lateral view.

7. *Myndus dolosus* sp. nov.; *a*, male genitalia with ædeagus dissected out, left lateral view; *b*, ædeagus, left lateral view.

8. *Myndus fasciatus* sp. nov.; *a*, male pygofer and anal segment, left lateral view; *b*, ædeagus and right genital style, right lateral view.

9. *Myndus brunneus* sp. nov.; ædeagus and right genital style, right lateral view.

10. *Myndus mundus* sp. nov.; ædeagus and right genital style, right lateral view.

11. *Myndus caligineus* sp. nov.; *a*, ædeagus, left lateral view; *b*, left genital style, lateral view.

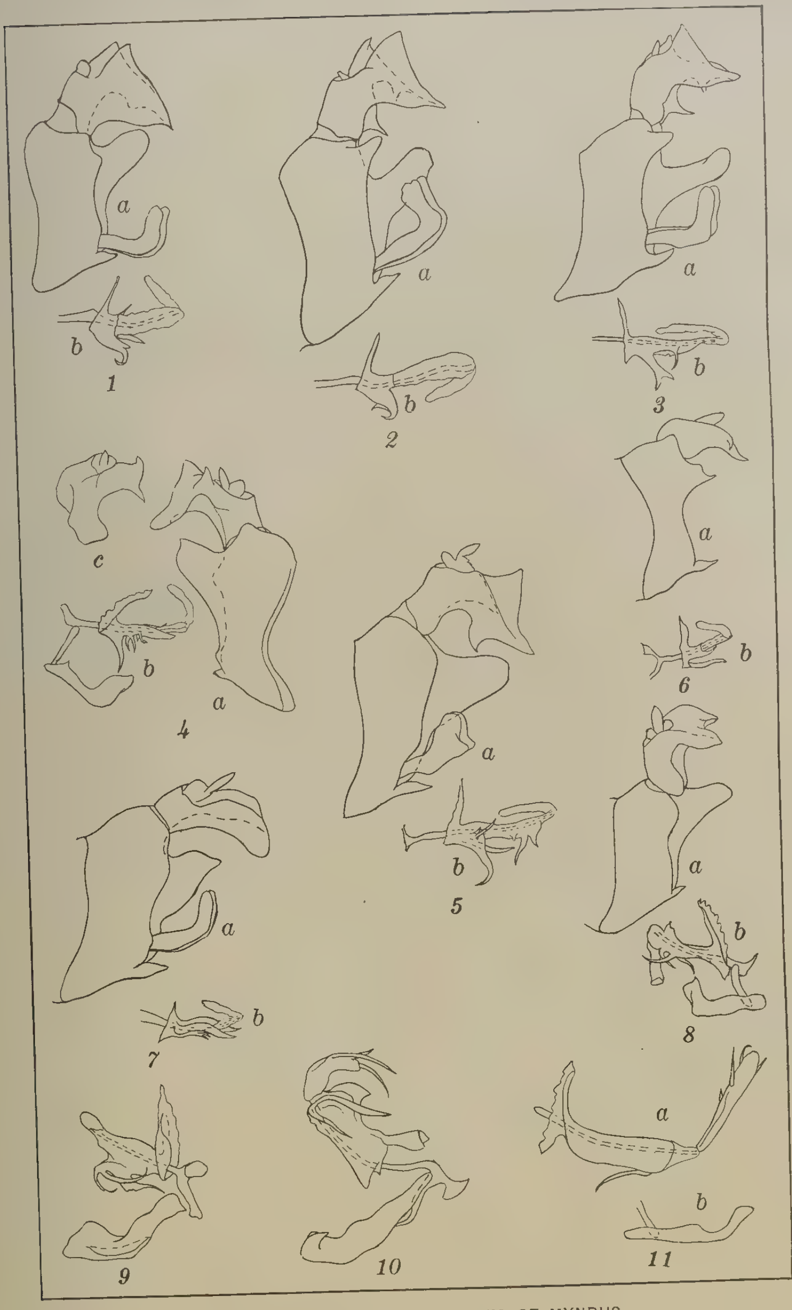

PLATE 1. GENITALIA OF SPECIES OF MYNDUS.

TWO COLLECTIONS OF FULGOROIDEA FROM SUMATRA

By F. Muir

Of the Hawaiian Sugar Planters' Experiment Station, Honolulu

ONE PLATE

Very little is known about the fulgorids of Sumatra, especially the small species, so the two small collections, one made by Mr. E. Jacobson and the other by Mr. J. B. Corporaal, are of interest. Besides the species mentioned, there are eight species of Cixiidæ which I am retaining for the present. The types are deposited in the Hawaiian Sugar Planters' Experiment Station collection in Honolulu.

ACHILIDÆ

Rhotala depressifrons sp. nov.

This species is similar in structure to *R. gravelyi* Muir from India, with the following exceptions. The vertex is narrower and longer, the base angularly emarginate with a fine carina, sides with carina rounded off at apex. Base of face smooth and shining, the lateral carinæ at base thickened, becoming slenderer to apex, having a triangular depression over the greater part of the face, a slight trace of a median carina on apical third. There is no trace of a suture dividing the posterior angle of the mesonotum and so it cannot be placed in the Tropiduchidæ, and the whole build and characters of the insect are achilid.

Female.—Length, 10 millimeters; tegmen, 11. Dark brown, with small lighter brown marks; legs with slightly lighter bands. Tegmina brown, with slightly dark brown mottlings, veins darker; wings light brown, with darker veins.

Pregenital plate large, short at sides, hind margin gradually produced to middle third which is steeply produced into a long, narrow process slightly bilobed at apex, with the sides curved dorsad, this middle process being as long as basal portion of pregenital plate; genital styles long, narrow, the anterior styles lying in the groove formed by the produced pregenital plate, the posterior pair straight, narrow, apex rounded, reaching nearly to apex of median process of pregenital plate. Anal segment small, longer than broad, rounded at apex.

SUMATRA, Bandar Baroe, November 26, 1919 (*J. B. Corporaal*), 1 female. Type No. 1059.

The venation of this genus is very distinct, the cubitus having six to eight apical veins.

CIXIIDÆ

Kinnara nigrocacuminis sp. nov. Plate 1, fig. 1.

In this genus vein R, after leaving Sc, joins M for a short distance.

Male.—Length, 2.6 millimeters; tegmen, 4.3. Stramineous; front tibiæ fuscous, abdomen dark brown, light on pleura. Tegmina hyaline, shiny, the apex from apex of Sc to apex of Cu1a dark fuscous; veins same color as membrane; wings hyaline, fuscous, veins dark brown.

Lateral processes of pygofer narrow, long, apex acute, curved, and slightly recurved. Anal segment large, length about three times the width, sides subparallel, anus near apex beyond which apex is narrowed to a point. Genital styles flat, narrow, curved, gradually narrowed to apex. Ædeagus complex with membranous filament at apex which appears to be common to this genus.

SUMATRA, Bandar Baroe, January 14, 1920 (*Corporaal*). Type No. 1060.

Borysthenes diversa (Distant).

SUMATRA, Bosehr Banda, January, 1920 (*Corporaal*), 1 female.

I identify this specimen as of this Indian species, but the male may show it to be different. The specimen is in bad condition but it agrees quite well with Distant's figure and description.

Kermesia maculata Melichar.

SUMATRA, Fort de Kock, June, 1921 (*E. Jacobson*), 1 male.

Eight other species of Cixiidæ await further study in connection with a large collection of this family from the Philippines.

DELPHACIDÆ

Ugyops notivena (Walker).

SUMATRA, Tandiong Merah, 1919 (*Corporaal*), 2 females.

Until the type of this species is redescribed and the male genitalia are examined there must be some uncertainty as to identification.

Melanesia sp.

SUMATRA, Paga Maban, December, 1919 (*Corporaal*), 1 female.

This appears to be an undescribed species, but the male is necessary for certainty.

Perkinsiella neoinsignis sp. nov. Plate 1, fig. 2.

In all external characters this species agrees with the Indian *P. insignis* (Distant), but the genitalia are quite distinct.

Opening of pygofer longer than wide, anal emargination large, anal angles not produced, medioventral margin produced into a small horizontally flat process deeply emarginate in middle, thus forming two flat processes; diaphragm long, dorsal margin V-shaped in middle. Anal segment large with two long, thin spines with their bases far apart. Genital styles not reaching to anal segment, apex truncate, narrow, inner margin straight on apical half, slightly concave on basal, outer margin concave on apical half, produced slightly on basal. Ædeagus large, flattened laterally, in lateral view curved, orifice on dorsal aspect of apex; basad of orifice there are two spinelike processes; one long, flat process curved to right, the other a small process slightly curved to left.

SUMATRA, Medan, 1920 (*Corporaal*), 1 male. Type No. 1061.

In *P. insignis* the medioventral process of pygofer is much broader and the two processes diverge slightly; the genital styles are much narrower at apex and gradually wider to basal angle; the ædeagus has two small spines about equal in size.

Dicranotropis corporaali sp. nov. Plate 1, fig. 3.

Male.—Length, 2 millimeters; tegmen, 2.4. The lateral carinæ of pronotum diverging posteriorly but not curved; median carinæ of face forked about one-third from base. Stramineous; mesonotum slightly sordid. Tegmina hyaline, slightly stramineous, veins same color as membrane, tubercles small, sparse, same color as veins bearing stramineous macrotrichia. Genitalia figured. The genital styles are very distinctive.

SUMATRA, Medan, 1920 (*Corporaal*), 1 male. Type No. 1062.

Phyllodinus platypoda (Dammerman).

SUMATRA, Fort de Kock, 920 meters elevation, November, 1920 (*Jacobson*), 1 female.

This species was originally placed in *Platybrachys* Dammerman, but that name is preoccupied. *Phyllodinus* Van Duzee as it stands at present consists of two genera and, until it is

straightened out, it is useless to give a new name to *Platybrachys* Dammerman.

Sogata furcifera (Horvath).

SUMATRA, Fort de Kock, 920 meters elevation, January, 1921 (*Jacobson*), 5 specimens.

This species has nearly a world-wide distribution. I have not yet placed it in any genus with any satisfaction but believe it is best placed in *Sogata*.

Nilaparvata greeni Distant.

SUMATRA, Fort de Kock, 920 meters elevation, January, 1921 (*Jacobson*), 3 males and 2 females.

The type of this genus, *N. greeni* Distant, is the same as *Dicranotropis anderida* Kirkaldy, and the same as what Melichar identifies as *Delphax sordescens* Motschulsky. I am deeply indebted to Doctor Bergroth for critical remarks and copies of the original descriptions of some of Motschulsky's species of *Delphax*. He suggests that possibly Melichar's identification of *D. sordescens* may not be correct. In this I quite agree with him and shall consider *greeni* as the type until the type of *D. sordescens* has been reëxamined.

This species has a wide distribution from Australia to India, China, and Formosa. The distinctive feature of the genus is two or three small spines on the hind basal tarsal segment.

Delphacodes striatella (Fall).

SUMATRA, Fort de Kock, February, 1921 (*Jacobson*), 1 male.

It is interesting to find this European species in Sumatra.

DERBIDÆ

Herpis borneensis Muir. Plate 1, fig. 4.

SUMATRA, Medan, October 20, 1920 (*Corporaal*), 1 male: Fort de Kock, November, 1920 (*Jacobson*), 1 female.

The genital styles are slightly more angular than in the type specimen. The ædeagus has not been dissected out.

Vekunta punctula (Melichar).

SUMATRA, Medan, January 31, 1921 (*Corporaal*), 1 female.

This specimen agrees with the description, but as no mention is made of the genitalia or even the sex, of the type, the identification remains uncertain.

Pregenital plate large, short at sides, the outer thirds of the hind margin nearly straight, the middle third produced into a

large process longer than broad, gradually widening from base to middle, then gradually narrowing to the rounded apex. Anal segment slightly longer than wide, apex broadly rounded. Genital styles fairly large, projecting beyond apex of pregenital plate.

Vekunta pseudobadia Muir.

SUMATRA, Medan, December 30, 1920 (*Corporaal*), 1 female.

Kaha perplexa (Muir).

SUMATRA, Medan, February, March, 1920 (*Corporaal*), 1 male and 3 females.

Proutista moesta (Westwood).

SUMATRA, Haboko, July 23, 1920 (*Corporaal*), 2 males: Mopoli Atjeh, September 15, 1920 (*Corporaal*), 1 female.

Zoraida cumulata (Walker).

SUMATRA, Atjib aloer Djombae, September 15, 1920 (*Corporaal*), 2 females.

The specimens are much damaged, but the genitalia enable me to identify this widely distributed species.

Zeugma corporaali sp. nov. Plate 1, fig. 5.

In size, general build, and color this species is similar to *Z. monticola* Kirkaldy (=*Z. vittata* Westwood?), but the genitalia are quite distinct. In *Z. corporaali* sp. nov. the ædeagus is longer and the apical, bifurcate portion has one large spine in the middle on the side and a broad, bifurcate or subcrescent-shaped process at apex; it also has a series of trifurcate spines. In *Z. monticola* Kirkaldy (Plate 1, fig. 6) the ædeagus is shorter and the apical portion has two small spines in the middle and a bidentate process at apex, and it has no trifurcate spines. The lateral margins of the pygofer are also distinct. The female of *Z. corporaali* differs from *Z. monticola* in having the basal margin of the pregenital plate raised into a rim instead of a small, raised rim forming a small arc slightly posterior to basal margin.

SUMATRA, Medan, December 5, 1918 (*Corporaal*), 1 male, and October 9, 1918 (*Corporaal*), 1 female. Type No. 1063.

This genus is now known from Formosa, the Philippines, Borneo, Java, Sumatra, Malay Peninsula, and India.

ILLUSTRATION

PLATE 1

FIG. 1. *Kinnara nigrocacuminis* sp. nov.; pygofer and anal segment of male, lateral view.

2. *Perkinsiella neoinsignis* sp. nov.; *a*, apex of ædeagus, dorsal view; *b*, right genital style.

3. *Dicranotropis corporaali* sp. nov.; *a*, genitalia of male, three-fourths view; *b*, anal segment and ædeagus, lateral view.

4. *Herpis borneensis* Muir; male genitalia, lateral view.

5. *Zeugma corporaali* sp. nov.; *a*, ædeagus; *b*, pygofer, lateral margin.

6. *Zeugma monticola* Kirkaldy; *a*, ædeagus; *b*, pygofer, lateral margin.

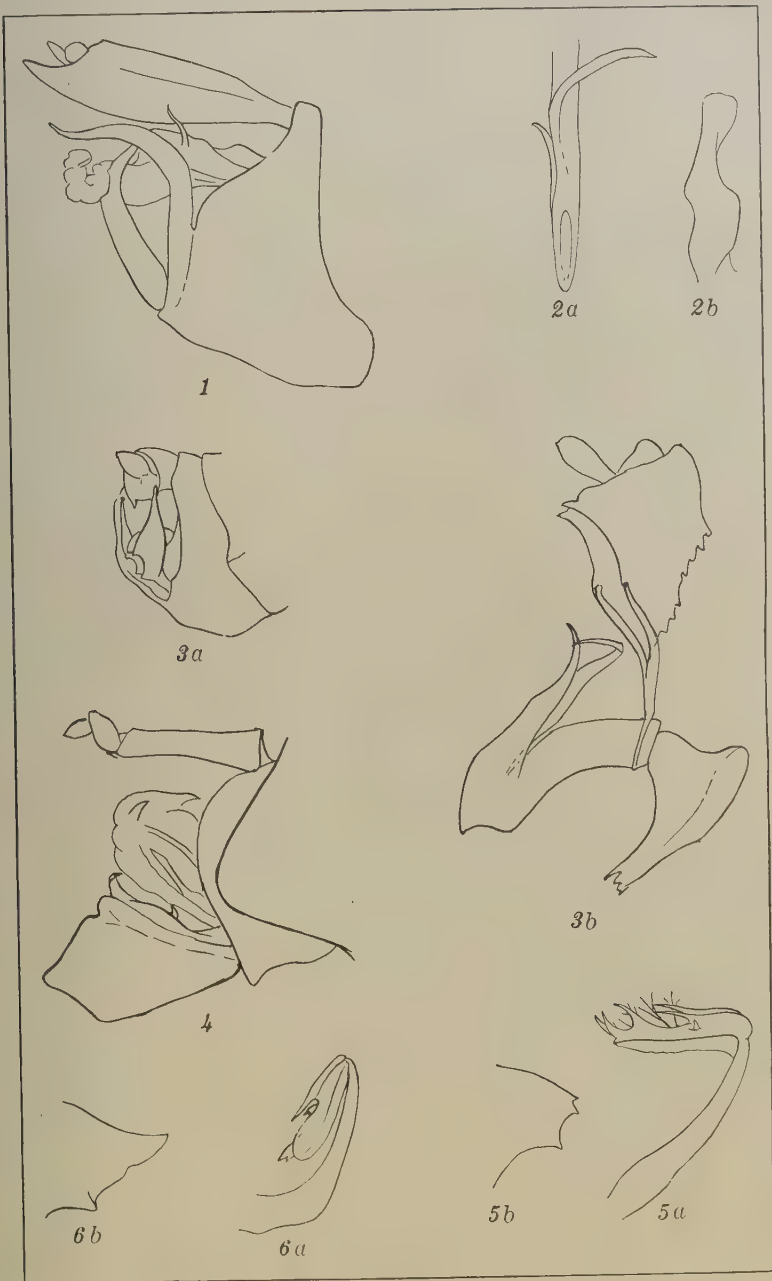

PLATE 1.

LYCOPODIACEAE BORNEENSES

Auct. W. HERTER
Berlin, Germany

Im Jahre 1921 sandte mir Herr Merrill, Director, Bureau of Science, Manila, P. I., vereint mit philippinischen Lycopodiaceen, deren Bearbeitung an anderer Stelle veröffentlicht wird,[1] auch eine kleine, sehr schöne Sammlung von Borneo-Lycopodiaceen. Die Pflanzen stammen zwar alle aus derselben Gegend der Insel Borneo, nämlich aus dem zwischen dem 2. und 7. Grad nördl. Breite gelegenen englischen Norden der Insel (British North Borneo und Sarawak), doch gibt die Sammlung einen guten Einblick in die Lycopodiaceenflora der grossen Insel, von der bisher nur spärliches Material in die Herbarien Europas gelangt ist, sodass es sich lohnt, dieselbe einer näheren Betrachtung zu unterziehen. Das Material enthält 15 Species, 12 *Urostachys-* und 3 *Lycopodium*-Arten. Davon ist besonders *U. selago* interessant, eine boreale Species, die zwar schon oft aus tropischen Gegenden angegeben, bisher aber noch nie mit Sicherheit nachgewiesen worden ist. Es hat sich vielmehr fast stets herausgestellt, dass es sich ebenso wie bei den extraeuropäischen Funden innerhalb des borealen Florenreichs (*U. lucidulus* und *porophilus* in Nordamerika, *U. sinensis, tenuifolius,* und *Delavayi* in Ostasien) auch bei den extraborealen Funden (*U. Hildebrandtii* auf Madagaskar, *U. saururoides* auf Ascension, *U. barbatus* in Costarica, *U. haleakalae* auf Hawaii, *U. miniatus* auf Java, *U. Christii* in Brasilien, u.s.w.) um eigene gute Arten aus der Gruppe *Selagina* handelt. Hier liegt indessen unzweifelhaft echter *U. selago* vor, anscheinend ein uralter Bewohner uralter Gebiete. Neu ist *U. borneensis,* Gruppe *Euphlegmaria,* wohl eine endemische Art. Die übrigen Arten sind dieselben, die auch auf den benachbarten grossen Sundainseln sowie auf den Philippinen und zum Teil auch auf Neu Guinea vorkommen, wie die Uebersicht auf Seite 183 erkennen lässt. Von den Philippinen wurden bisher 22 (15 *Urostachys* + 7 *Lycopodium*) Arten, von Neu Guinea 18 (14 + 4) Arten bekannt; erstere beherbergen 6 (5 + 1), letzteres beherbergt 8 (8 + 0) Endemismen.

[1] Philip. Journ. Sci. 22 (1923) 57–76.

Genus **UROSTACHYS** (Pritz.) Herter

UROSTACHYS SELAGO (L.) Hert. comb. nov.

Lycopodium selago Linn. Sp. Pl. (1753) 1102.

Optime congruit cum speciebus europaeis. Plantae robustae bulbillis praeditae.

British North Borneo, Mount Kinabalu fl. Jul., Aug., 1916, *Haslam s. n.;* Paka Cave to Low's Peak, fl. Nov., 1015, *Topping 1688,* elev. 4,000 m., fl. Nov., 1913, *Clemens 10613;* Paka Cave to Lobang, fl. Nov., 1915, *Clemens 10714.*

UROSTACHYS SERRATUS (Thunb.) Hert. in Philip. Journ. Sci. 22 (1923) 61.

British North Borneo, Mount Kinabalu, Kiau, fl. Oct.–Nov., 1915, *Topping n. 1564;* along trail on ground, fl. Nov., 1915, *Clemens 10235;* Marai Parai Spur, ridge trail, fl. Dec., 1915, *Clemens 11052;* Gurulau Spur. fl. Nov., 1915, *Topping 1628.*

UROSTACHYS SQUARROSUS (Forst.) Hert. in Philip. Journ. Sci. 22 (1923) 62.

British North Borneo, Mount Kinabalu, Kiau, fl. Nov., 1915, *Topping 1635, Clemens 9957, 9987;* Kiau to Lobang, fl. Nov., 1915, *Topping 1582;* Keung, river bank, fl. Dec., 1915, *Clemens 9890.*

UROSTACHYS WHITFORDI Hert. in Philip. Journ. Sci. 22 (1923) 63.

British North Borneo, Labang, Soeda, fl. Oct., 1912, N. Borneo Boundary Commission, *Capt. V. Ganderen (coll. Amdjah) 274:* Sarawak, *Native collector 59, 1516.*

An potius species propria affinis *U. squarroso* (Forst.) Hert. diversa a speciebus philippinensibus *U. Whitfordi* Hert. et *U. Magnusianus* Hert. ? Confer species novoguineenses U. Hellwigi (Warb.) Hert. nov. comb. et U. Lauterbachi (Pritz.) Hert. nov. comb. [*Lycopodium Hellwigi* Warb. Monsunia 1 (1898), *Lycopodium Lauterbachi* Pritz.]

UROSTACHYS CARINATUS (Desv.) Hert. in Philip. Journ. Sci. 22 (1923) 64.

Borneo, ster., Korthals ex Herb. Lugd. Bat.: Sarawak, ster., *Native collector 60, 967;* Lundu, Santubong, fl. May, 1908, *Foxworthy 116, 330.*

UROSTACHYS PINIFOLIUS (Blume) Hert. in Philip. Journ. Sci. 22 (1923) 65.

Sarawak, *Native collector 73.*

Planta juvenilis s. forma specialis, similis Mindanao, Lake Lanao, Camp Keithley, fl. Jul. 1907, *Clemens s. n.*

UROSTACHYS ELMERI Hert. in Philip. Journ. Sci. 22 (1923) 65.

British North Borneo, Kalabakan, in forests on *Canarium* tree, alt. 150 m, fl. Sept., 1916, *Villamil 210.*

An species distincta, affinis U. phyllantho (Hook. & Arn.) Hert. comb. nov. *Lycopodium phyllanthum* Hook. & Arn. Bot. Beechey Voy. (1841) 103.

UROSTACHYS BANAYANICUS Hert. in Philip. Journ. Sci. 22 (1923) 66.

British North Borneo, Mount Kinabalu, Kiau, fl. Nov., 1915, *Clemens 10242.*

UROSTACHYS PLEGMARIA (L.) Hert. in Philip. Journ. Sci. 22 (1923) 66.

British North Borneo, Mount Kinabalu, fl. Jul.–Aug., 1916, *Haslam s. n.;* Keung to Kibayo, fl. Nov., 1915, *Topping 1909;* Kiau, fl. Nov., 1915, *Clemens 10107;* Mount Tuaran, forest trail, fl. Dec., 1915, *Clemens 11271:* Sarawak, *Native collector 54, 57, 773, 964, 966;* Baram District, fl. Nov., 1894, *Charles Hose 723;* Mount Sudan, fl. Feb.–Jun., 1914, *Native collector 2087;* east of Bukit Trumat, near Pentop, *Native collector 1515* pp. cum *U. borneensi.*

UROSTACHYS BORNEENSIS Hert. sp. nov.

Radix fasciculata. Frons luteo-viridis, quater bipartita, pendula, flaccida, long. 10–20 cm, lat. 8–12 mm. foliis inclusis. Caulis flaccidus, basi 1 mm lat. foliis exclusis. Flores flaccidi, bipartiti, long. 4–5 cm, lat 1.2 mm. Folia sparsa, ± sexfaria, 6–15 pro cm, axim non tegentia, horizontaliter patentia, ovato-lanceolata, acuminata, nitida, plana, non carinata, abruptim in sporophylla transeuntia, 1–3 x 4–6 mm. Sporophylla densa, ovato-lanceolata, erecto-appressa, sporangia subtegentia, 0.5 x 1 mm. Sporangia vix 1 mm lata.

Sarawak, *Native collector 1515 p. p., 1540,* cum *U. phlegmaria* Hert.

Species distinctissima affinis *U. Ledermanni Hert.* et *U. flagellaceo* (Kuhn) Hert.

UROSTACHYS SALVINIOIDES Hert. in Philip. Journ. Sci. 22 (1923) 67.

A typo philippinensi satis diversa, an species propria?

British North Borneo, Mount Kinabalu, fl. Jul.–Aug., 1916, *Haslam s. n.;* Gurulau Spur, summit, fl. Nov., 1915, *Clemens 10778;* Mount Bungal, fl. Dec., 1915, *Clemens 11216.*

UROSTACHYS NUMMULARIIFOLIUS (Blume) comb. nov.

Lycopodium nummularifolium Blume Enum. Pl. Jav. (1828) 263.

Sarawak, *Native collector 58, 774, 1547, 1548;* Amproh River, fl. Feb.–Jun., 1914, *Native collector 2143:* British North Borneo, Mount Kalawat, on ant's nest, fl. Dec., 1915, *Clemens 11144.*

Genus LYCOPODIUM (L.) Herter

LYCOPODIUM SCARIOSUM Forst. Prodr. Florul. Ins. Austral. (1786) 87.

British North Borneo, Mount Kinabalu, Paka Cave, fl. Nov., 1915, *Topping 1674, 1700;* Paka Cave to Low's Leak, fl. Nov., 1915, *Topping* fl. Nov., 1915, *Clemens 10651;* Paka Cave to Lobang, erect *Lycopodium* under shrubbery, fl. Nov., 1915, *Clemens 10730,* fl. Jul.–Aug., 1916, *Haslam s. n.*

LYCOPODIUM CERNUUM L. Sp. Pl. (1753) 1103.

Var. **CAPILLACEUM** Spring Monogr. Lycop. 1 (1842) 80. [*L. bryifolium* Ventenat mscr.—*? L. marianum* Desv. mscr.—*L. cernuum β laxum* Blume En. Pl. Jav. 2 (1828) 266.]

Forma **TYPICA** Hert. f. nov.

Differt floribus brevibus (3 x 6–8 mm), fronde 6–8 mm lata.

British North Borneo, Sandakan, in shallow moist cave at base of sandstone cliff, fl. Oct., 1908, *Foxworthy 576*; fl. Oct., 1915, *Topping 1366.*

Forma **LONGIFLORA** Hert. f. nov.

Differt floribus longibus (2 x 16–18 mm), fronde 3–4 mm lata. Planta distinctissima.

British North Borneo, Sandakan, fl. Oct., 1908, *Foxworthy 582.*

Var. **VULCANICUM** Hert. var. nov. [*? L. curvatum* Sw. Syn. Fil. (1806) 178 & 402; *? L. cernuum β curvatum* Hook. & Grev. En. Fil. (1831) n. 34;—*? L. convolutum* Desv. ex. Lam. Enc. Bot. Suppl. 3 (1813) 546—*L. curvatum & vulcanicum* Blume En. Pl. Jav. 2 (1828) 266—*L. cernuum δ crassifolium & L. curvatum* Spring Monogr. Lycop. 1 (1842) 80 & 81—*? L. marianum* Willd. mscr.—*L. cernuum* forma *vulcanica* Hert in Engl. Bot. Jahrb. **54** (1916) 235.]

Differt fronde rigidissima.

Hic forma *ramosissima* Hert. in Engl. Bot. Jahrb. 54 (1916) 235.

Labuan, fl. Nov., 1902, *Merrill n. n.:* British North Borneo, Kiau, fl. Nov., 1915, *Clemens 10228;* Gurulau Spur, fl. & ster. Nov., 1915, *Clemens 10806, 10852, 10881;* Sandakan, ster. Oct., 1915, *Topping 1357,* Marai Parai Spur, ster., Nov., 1915, *Topping 1875;* Paka Cave, ster., Nov., 1915, *Topping 1673;* Jesselton,

fl. Oct., 1915, *Topping 1461;* on hillside 25–50 m alt., fl. Oct., 1917, *Yates 67;* brushland, 120 m alt., fl. Feb., 1916, *Villamil 139.* Sarawak, *Native collector 766, 1863, 1973;* summit of Mount Murud, fl. Dec., 1914, *Native collector 2857, 2858.*

LYCOPODIUM CASUARINOIDES Spring Monogr. Lycop. 1 (1842) 94.

British North Borneo, Mount Kinabalu, Paka Cave to Lobang, ster. Nov., 1915, *Topping 1754;* Kemberanga, covering shrubbery, ster., Nov., 1915, *Clemens 10520,* ster., Jul.–Aug., 1916, *Haslam s. n.*

ÜBERSICHT ÜBER DIE LYCOPODIACEEN VON BORNEO, VON DEN PHILIPPINEN, UND VON NEU GUINEA

Die Endemismen sind fett, die sonstigen, nur in einem der drei Gebiete gefundenen Arten sind cursiv gedruckt.

Genus Urostachys.

	Sectio.						
	Selaginurus.	*Tenuifoliurus.*	*Linifoliurus.*	*Squarrosurus.*	*Carinaturus.*	*Phlegmariurus.*	*Nummulariifoliurus.*
Borneo	**selago.** *serratus.*			*squarrosus.* *Whitfordi.*	*carinatus.*	*pinifolius.* *Elmeri.* *banayanicus.* *phlegmaria.* *salvinioides.* **borneensis.**	*nummulariifolius.*
Philippinen	**minimus.** *serratus.*	*verticillatus.*		*squarrosus.* **Magnusianus.** *Whitfordi.* **Toppingi.**	*carinatus.*	**Merrilli.** *pinifolius.* *Elmeri.* *banayanicus.* *phlegmaria.* *salvinioides.*	**Delbrückii.**
Neu Guinea	*serratus.*	*verticillatus.*	**bolanicus.**	*squarrosus.* **Hellwigi.** **Lauterbachi.**	*carinatus.*	**Dielsi.** **terrae.** **guilelmi.** **coralium.** *phlegmarioides.* **Ledermanni.** **flagellaceum.**	*nummulariifolius.*

Genus Lycopodium.

	Sectio.			
	Clavatostachys.	*Complanatostachys.*	*Cernuostachys.*	*Lateralistachys.*
Borneo		*scariosum.*	*cernuum.* *casuarinoides.*	
Philippinen	*clavatum.*	*complanatum.* *scariosum.*	*cernuum.* *casuarinoides.* *volubile.*	halconense.
Neu Guinea	*clavatum.*	*complanatum.* carolinianum.	*cernuum.*	

MERRILLOSPHAERA AFRICANA AT MANILA

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SEVEN PLATES

CONTENTS

INTRODUCTION

In preparing accounts of the larger Volvocaceae found at Manila I have left to the last a species that can be easily put in its place beside its nearest relatives in the family. This is the species that was described by West ('10) from Albert Nyanza, in Africa, under the name *Volvox africanus* and afterwards reported from the Ussangu Desert, also in Africa, by Rousselet ('14) who submitted material containing sexual coenobia to West for description (West, '18). This species, with others, was collected by Dr. M. A. Barber in the vicinity of Manila in July, 1914, and by myself at various later times, and is represented in my bottles, preparations, and micrographs by examples in most of the varied stages of the life cycle of the species, and with a diversity of form considerably greater than was shown by the material described by West from Africa.

Material associated with this species, and in most cases more or less abundantly mixed with it in the ponds, bottles, and preparations, led me to propose the separation from *Volvox* of those species in which the somatic protoplasts are without protoplasmic connecting filaments. Some of those species have their gonidia, the asexual reproductive cells, differentiated at an early

stage in the development of the asexually produced embryos, and they seem to form a natural group.

The most unique of these species exhibited a migration of the gonidia from the outside to the inside of the embryo through the phialopore shortly before the closure of that opening in the wall of the forming sphere. That species I have described (Shaw, '19) under the name *Campbellosphaera obversa.*

A species, so similar to *Campbellosphaera obversa* that for a long time the two were confused in my notes, was found to lack the migration of the gonidia and to possess other distinctive characters, and was proposed for the type of another genus, *Merrillosphaera* (Shaw, '22B). This species proved identical with *Volvox carteri* Stein ('78 *V. globator* Carter '59), and the largest Philippine form was described under the trinomial *Merillosphaera carteri* var. *manilana.* It was pointed out that *Volvox weismannia* (Powers, '08) is at most another variety of the same species, and that one of the forms described by Klein ('89B) from material collected by Migula may be regarded as another species under the name *migulae.*

In *Volvox africanus* from Albert Nyanza no protoplasmic connections between the protoplasts were observed by West ('10), and none have been found in my numerous collections of the species. My material reveals the fact that the gonidia are differentiated at an early stage of the embryonic development and attain a large size before segmenting in their turn, but do not migrate through the phialopore of the embryo. Mainly on the ground of these characters I assigned the species to the recently erected genus under the name *Merrillosphaera africana.*[1]

ORIGINAL DESCRIPTION AND ILLUSTRATIONS

The original description by West was based on asexual material obtained from Albert Nyanza by Mr. R. T. Leiper in 1907, and sent to West by Dr. W. A. Cunnington and Mr. C. F. Rousselet. It was illustrated by three photomicrographs (West, '10, pl. 3, figs. 8 to 10) that are herewith reproduced[2] on a larger scale (Plate 7, figs. 48 to 50). These show ovoid coenobia with dimensions, as indicated by the stated magnifi-

[1] A preliminary announcement of this was made in a footnote to a previously published paper (Shaw, '19, p. 512).

[2] Through the kindness of Prof. R. H. Yapp and Miss Nellie Carter, of the botanical department of the University of Birmingham, photographic prints from West's negatives have been provided for the reproduction of his figures with this paper.

cation, of about 455 by 525 μ, 420 by 490 μ, and 475 by 595 μ. The somatic cells show most clearly about the anterior poles where they are most widely spaced. In West's figure 10 (Plate 7, fig. 48) the somatic protoplasts are about 5 or 6 μ in diameter, and near the anterior pole they are spaced about 25 μ between centers. On the sides of the coenobium the spacing is about 19 to 21 μ. The number of somatic cells I estimate to be between 2,000 and 2,500. West described the cells as having no observable protoplasmic connections.[3]

The daughters, as shown by his micrographs, are three, four, and three, respectively, and the granddaughters two, two, and three in his figure 8 (Plate 7, fig. 49); four in one and probably all of the daughters in his figure 9 (Plate 7, fig. 50); and three, four, and four in his figure 10 (Plate 7, fig. 48). The latter figure shows within the granddaughters the fourth generation, but not sufficiently clearly for counting the great granddaughters or for determining whether they are gonidia or embryos.

The daughter coenobia, except when an odd one is present, occur in pairs and are compressed between their sisters and the wall of the mother coenobium. The mothers in West's figures 8 and 10 (Plate 7, figs. 49 and 48) have each one pair of larger and more-elongated daughters a little in advance of the middle of the mother, and an unpaired smaller daughter in the back part of the mother. Each of the larger, paired daughters is longer than half the length of the mother and narrower than half the width of the mother. As the transverse diameters which they show in the picture plane are shortened by compression against their sisters, their transverse diameters normal to the picture plane are probably considerably greater. The mother shown by West's figure 9 (Plate 7, fig. 50) has two pairs of daughters that lie in median planes normal to one another, the members of the pair near the middle being somewhat larger than those of the pair in the back, but all having dimensions considerably less than half as great as the corresponding measurements of the mother coenobium.

The granddaughters show the pairing also. One larger daughter in West's figure 8 (Plate 7, fig. 49) contains only a pair of globose granddaughters about 50 and 57 μ in diameter, this being about a quarter of the width of the daughter. They

[3] His mention in a later paper (West, '18, p. 426) of delicate connecting strands of protoplasm seems to have been a slip.

are located on opposite sides a little in advance of the middle of the daughter. There are three granddaughters in the other larger daughter and two in the smaller daughter; but, some of them being out of focus, their relative sizes do not show. In figure 9 (Plate 7, fig. 50) one of the daughters is clearly shown to contain four granddaughters and the others appear to contain the same number, all of which have diameters one-eighth or less of the dimensions of their mothers. The granddaughters in figure 10 (Plate 7, fig. 48) are four and three in the paired daughters, and four in the smaller daughter. The clearest picture of the fourth generation is one in the right member of the pair in the same figure, the globose granddaughter being about 65 μ in diameter, and the fourth generation, whether gonidia or embryos, about 12 μ in diameter.

The tendency to have the daughters grouped into a larger pair in the middle of the mother and a smaller pair farther back is probably more marked in the species than appears in the photomicrographs, and I believe that it may properly be regarded as a character of the species represented by the figures. West ('10) recorded having observed coenobia in which only a single daughter was present, and stated that in such cases the daughters were ovoid although free from compression by sisters.

A male coenobium observed by West ('10) in company with the asexual coenobia presented no means by which it could certainly be identified as of the same species. The material contained no female coenobia.

FEMALE COENOBIA FROM AFRICA

Female coenobia of this species were found in plankton material collected by Dr. A. W. Jakubski, of Lemberg, from small temporary pools in the Ussangu Desert, in what was then German East Africa, on his trip of 1909–10. Mr. C. F. Rousselet ('14), who discovered them, turned them over to West for description. In describing them West ('18) gave photomicrographic figures of two female coenobia with ripe oospores. These figures are reproduced herewith (Plate 7, figs. 51 and 52).

These coenobia are ovoid-ellipsoidal, and measure about 565 by 660 μ and 600 by 780 μ. Oospores are absent from the anterior fifth of the coenobium, and the number of oospores in each coenobium appears to be about 40 (39 and 41). West ('18) gave 70 to 80 (average 74) as the number of oospores in a coenobium. The number of cells in a coenobium he stated as 3,000 to 8,000 and the number of daughter coenobia as 1

to 4. The somatic cells are described as 8 to 9.5 μ in diameter, almost globose, with long delicate connecting strands of protoplasm. These connecting strands are mentioned only in a tabulation of characters of the species in contrast with characters of *Volvox rousseleti* which has relatively broad connecting strands. It appears to me that the ground for ascribing such connecting strands to this species was purely an assumption that, since they are present in a supposedly similar European species, they are therefore probably present in this one also.

The oospores measure about 45 μ in diameter and have thick smooth walls.

No male coenobia were observed that could be definitely connected with the species.

TYPICALLY OVOID COENOBIA AT MANILA

ASEXUAL COENOBIA

Philippine material that closely resembles the African coenobia described and figured by West was obtained from a small pond in Pasay, near Manila, October 19, 1914. This pond, designated by the letter I in my notes, was about half a meter deep and 6 meters across, and at that time it was shrinking, as the rainy season was drawing to a close.

Nine asexual coenobia from this material are shown in Plate 1, figs. 1 to 6, and Plate 2, figs. 7, 9, and 12. The first six of these contain only asexual progeny, and their pictures do not bring out any characters not given by West in his description of the African material. Direct observation of the specimens, however, brings out the fact that most of the third generation that is represented in these coenobia are still undivided gonidia. The oldest of the six is the only one in which gonidia of the daughters have divided, and in that one there is an undivided gonidium in each daughter.

Study of the specimens reveals another point that was not brought out by West. In coenobia with less than two pairs of daughters or gonidia, absent members that would be required to make up this number are commonly represented by abortive gonidia which are located in the places where, from the arrangement in cases where two pairs are present, gonidia would be expected to occur. Some notes on these specimens will now be recorded.

Specimen 1.—Plate 1, fig. 1. This is an asexual coenobium with one daughter containing two gonidia. In the picture a

vacancy can be seen in the layer of somatic cells opposite the daughter. The slide bearing this specimen dried up before it was studied closely.

Specimen 2.—Plate 1, fig. 2. This is an asexual coenobium with two daughters, each with a gonidium of 53 μ in its left side and an embryo in the right side. The embryo in the left daughter is 8-celled and measures 54 μ, and that in the right daughter is 2-celled and measures 53 μ. On the nearer and the farther sides of the mother, at the level of the lower ends of the daughters, near the median plane of the picture, there is a cell with the protoplast about twice the size of a somatic protoplast sunken beneath the level of the somatic layer. The positions of these two cells indicate that they are a posterior pair of abortive gonidia. There is a similarly enlarged protoplast in the wall of the mother over that part of the left daughter midway between the reproductive bodies and the lower end. This protoplast is not sunken below the level of its neighbors, possibly because of interference by the daughter. In the daughter at the left there are two small reproductive bodies that do not show in the photograph. They are in the hindmost (lower) half of the coenobium and measure about 12 μ wide. One is nearer the hinder pole than is the other, and they are both nearly in the same plane with the larger reproductive bodies. In the hinder (upper) part of the right daughter there are three diminutive reproductive cells smaller than those in the left daughter. This specimen and the other larger ones of this series are greatly flattened and broadened by the cover glass.

Specimen 3.—Plate 1, fig. 3. This is a somewhat younger asexual coenobium with two asexual daughters, each having three prominent gonidia. The gonidia measure 60, 57, and 46 μ in the left daughter and 53, 53, and 42 μ in the right daughter. In the mother coenobium, midway between the lower ends of the daughters and the hinder pole of the mother, there are two abortive reproductive cells, one a little more and the other a little less than twice the diameter of their neighboring somatic cells below the level of which they are sunken. Between the nearer abortive body and the lower end of the left daughter there is a group of three somatic cells that are enlarged to about one and a half times the diameter of the neighbor cells. But they are not sunken. In each daughter there is, besides the prominent reproductive bodies, a small one of about 11 μ near each of the large ones. The small body in the back

part of the daughter may be a vestigial mate of the larger one, and the two near the middle may be a vestigial second equatorial pair of gonidia.

Specimen 4.—Plate 1, fig. 4. This is an asexual coenobium with a pair of daughters, each containing two pairs of gonidia. It was in a preparation that dried before being closely studied.

Specimen 5.—Plate 1, fig. 5. This is another asexual coenobium with two daughters. The one at the left contains two pairs of gonidia, and the one at the right contains a pair of larger gonidia and a single smaller one. The specimen was ruined by a bubble before being examined for abortive reproductive bodies.

Specimen 6.—Plate 1, fig. 6. This is an asexual coenobium with a pair of larger daughters and a single smaller one. The mother contains also, on the farther side and partly hidden by the smaller daughter, a reproductive body about 18 μ wide that appears to be divided into four cells. It is in the position that would have been occupied by the mate of the smaller daughter had there been one developed. In the right daughter there are two and in the lower daughter there is one of the abortive reproductive bodies in addition to the large ones that appear in the picture.

Specimen 7.—Plate 2, fig. 7. This is an asexual coenobium containing a bisexual, a male, and an asexual daughter. The bulging of the sides of the mother is partly due to flattening under the cover glass. The asexual daughter contains three prominent gonidia, two of 55 μ and one of 35 μ. Damage by the crowding of a bubble has made it impossible to look for a vestigial mate of this smaller daughter. The asexual daughter is headed backward and the others are headed forward, and all show absence of reproductive bodies in their anterior ends. The sexual daughters will be described under another heading.

Specimen 8.—Plate 2, fig. 9.[4] This is an asexual coenobium with two daughters, one sexual and the other asexual. The mother has, on the nearer and the farther sides on a level with the lower ends of the daughters and in the median plane of

[4] The unfortunate arrangement of the figures that illustrate this paper in a different order from that in which the specimens are treated in the paper resulted partly from a decision to use a uniform magnification of one hundred diameters, partly from a war-time effort to economize plate area. After the plates had been made up there accumulated notes that refer to the figures by number and render it undesirable to alter their arrangement.

the picture, an abortive gonidium with diameters about two and a half times as great as those of the neighboring somatic protoplasts. They are sunken below the somatic layer. The asexual daughter contains two embryos and one gonidium. The gonidium is the smaller body and measures about 46 μ. It has a very small vestigial mate of about 7 μ. The embryos are about in the 8- and 4-celled stages. Their details do not show very clearly through the coenobium walls of the mother and the daughter. The female daughter will be described under another head.

Specimen 9.—Plate 2, fig. 12. This is an asexual coenobium with three sexual daughters in which female reproductive bodies predominate. The daughters are all headed forward with the mother, and all show absence of reproductive bodies in their forward parts. On the farther side of the mother, on a level with the middle of the smaller daughter, there is an abortive gonidium of about 13 by 16 μ. The daughters will be described with the female coenobia. On the same slide with this specimen there is another with three female daughters of similar proportions and one with four that form a pair of larger and a pair of smaller ones.

These nine specimens illustrate the fact that in this material the asexual coenobia bear from one to four gonidia that are already large in embryonic coenobia and reach a very great size before dividing. When four are present they form two pairs, a pair of large ones on opposite sides of the middle of the coenobium and a pair of smaller ones on opposite sides of the hindmost half, third, or quarter of the coenobium and in or near a longitudinal plane normal to the longitudinal plane passing through the other pair. When only three gonidia are present it is usually one of the smaller pair that is absent, and when only two are present it is usually both of the smaller pair that are absent. When only one is present it is usually one of the larger pair, and the daughter produced occupies only its own side of the mother. The absent members, when less than four are present, are represented by what may fairly be regarded as abortive gonidia of about one and a half to three times the diameter of the somatic protoplasts, that are formed in the coenobium wall at places where gonidia would be expected and sink below the level of the neighboring somatic cells. Indications are not wanting that some of these coenobia contain traces of a third pair of gonidia located in nearly the same

transverse plane as the larger gonidia. These were noted in both daughters of specimen 3.

FEMALE AND BISEXUAL COENOBIA

The above heading was written before it had become apparent that the coenobia for which it is intended are not all strictly female, since some of them contain a few antheridia. It will be convenient to consider here those coenobia in which the female reproductive bodies greatly preponderate. Observations on the unborn daughters in the last three specimens will first be recorded.

Specimen 7a.—Plate 2, fig. 7. The female daughter in this specimen contains twenty-three oogonidia that range from 25 to 29 μ, and three reproductive bodies that I take to be androgonidia. Two of the latter are undivided and measure about 18 μ, and the other is divided into four cells and measures about 21 μ. The undivided supposed androgonidia are the two smaller bodies, one to the left and above the center, the other to the right and below the center. The first is on the nearer side, the other on the farther side of the coenobium. Their positions are about those of a typical pair of larger gonidia in an asexual coenobium. The third supposed androgonidium is farther back and to the left. Examination of the preparation from the back of the slide revealed, in the place that would be occupied by a symmetrically placed mate to the dividing androgonidium, a reproductive cell of about 20 μ in diameter.

Specimen 8a.—Plate 2, fig. 9. The female daughter in this mother contains twenty-three oogonidia of 21 to 28 μ in diameter, and two reproductive cells of about 18 μ in diameter. The latter are the bodies at the extreme right and left in about the middle of the coenobium. They are obviously homologous in position with the larger reproductive bodies of the asexual sister coenobium. In all probability they are androgonidia.

Specimens 9a, 9b, and 9c.—Plate 2, fig. 12. The three female daughters of specimen 9 contain thirty, seventeen, and twenty-nine reproductive bodies. In the two larger daughters two of the bodies are androgonidia, of which those in one coenobium are divided. In the left daughter (9*a*) the androgonidia are the upper, obscure member of a pair at the extreme left of the coenobium, and the lower member of a triad at the extreme right of the coenobium. They are fairly symmetrically located on opposite sides of the middle of the coenobium. These two

androgonidia measure about 18 μ, and the twenty-eight gonidia measure 21 to 28 μ. In the right daughter (9*b*) the androgonidia are the obscure smaller member of a pair at the left, and the smaller body at the right side of the middle of the coenobium. The one at the left is 4-celled and measures 21 μ, the one at the right is 2-celled and measures 18 μ. The fifteen oogonidia are 21 to 28 μ wide. In the small daughter (9*c*) the twenty-nine reproductive bodies measure from 18 to 21 μ. No androgonidia are distinguishable.

Specimen 10.—Plate 2, fig. 11. This is a free bisexual coenobium that is immature. It contains twenty-nine oogonidia of about 30 μ in diameter and two androgonidia. Of the latter the one at the left is on the farther side a little above the middle. It is divided into an immature platelet of thirty-two cells that measures 26 μ across. The one at the right is on the near side and is obscured by being in front of the upper member of the twin oogonidia at the extreme right of the coenobium. It is about 19 μ in diameter. In this coenobium there are numerous cells that are larger than typical somatic cells distributed like androgonidia in a male coenobium. They measure about 8 μ, and the somatic cells 4 to 6 μ.

Specimen 11.—Plate 2, fig. 10. This is a nearly mature sexual coenobium with twelve oospores that range from 39 to 43 μ wide. They have smooth spore walls that appear to be about 3 μ thick. Unfortunately, the specimen has become too much crushed by a bubble to admit of determining whether antheridial sites are present.

Specimen 12.—Plate 3, fig. 15. This coenobium contains about twenty-seven oospores that can be counted in the photograph. Each of the four spores that are black in the picture has another behind it. The preparation dried up before the specimen was studied in detail. One of the spores is shown more highly magnified in Plate 3, fig. 16. Its diameter is about 40 μ. This spore is the upper one on the left side of the coenobium. In the photograph two somatic protoplasts below the left side of the spore are in fairly sharp focus. The cells that look like ghosts are below the focal plane and those that show as dark shadows are above that plane. Although the spore appears to be in sharp focus it was probably somewhat below the focal plane. This is indicated by the fact that the somatic cells most nearly in focus are on diametrically opposite sides of the spore. To the right from the spore there is a vacancy

in the somatic layer; in fact, there appears to be a pair of such vacancies, of the sort that mark antheridial sites.

Specimen 13.—Plate 3, fig. 17. This coenobium contains thirty-one oospores by count under the microscope. There appears to be an antheridial site a little above and near the center of the picture. Examination from the back of the slide revealed a similar vacant space on the opposite side of the coenobium. There is a similar vacancy halfway to the left side and a little below the middle of the coenobium. It is obscured by a spore directly behind it on the opposite side of the coenobium. The oospores have smooth walls of about 41 μ in outside diameter and about 2 μ in thickness, and contain a protoplast of which the denser portion is about 33 μ in diameter. Four of the spores are shown more magnified in Plate 3, fig. 18. A slightly wavy appearance is produced by the shadows of overlying somatic cells.

Specimen 14.—Plate 6, fig. 46. This is an immature coenobium containing thirty-two oogonidia of about 37 μ in diameter and an antheridium consisting of a sperm platelet. This sperm platelet is a little above and to the left of the center of the picture. The platelet consists of sperms, but whether the group is still complete, and whether nearer to sixty-four or to one hundred twenty-eight, I am unable to make out. On the opposite side of the coenobium there is an empty antheridial site that is symmetrically located with reference to the antheridium.[5] Below the middle of the coenobium and halfway to the left there is another vacancy like an antheridial site.

Specimen 15.—Plate 6, fig. 47. This is the most mature of all the female coenobia figured. Like all the other coenobia of this series it is very much compressed under the cover glass, having a thickness of only about 56 μ. It measures 545 by 650 μ, being longer and broader than when the picture was taken. It then measured 515 by 620 μ, and its dimensions before compression were probably nearer 500 by 600 μ. The spacing of the somatic cells ranges from about 23 μ forward to about 10 μ at the back. Taking 570 μ as a mean diameter and 14 μ as the average spacing of the cells, we get 6,000 as the number of cells. This may be too high on account of the flattened condition of

[5] This was overlooked until the preparation was studied from the back by the use of a Zeiss achromatic objective B (12 millimeters equivalent focus).

the coenobium. There are twenty-seven oospores in the coenobium. They have smooth walls that measure about 43 μ in outside diameter and about 37 μ in inside diameter. Some of the oospores that appear in pairs are on the same side of the coenobium, and some are on opposite sides. Some of the closest pairs are on the same side, but so far as can be made out they do not arise from contiguous cells in the somatic layer. They are, therefore, not sister cells. At the middle level of the coenobium there is an antheridial site on the nearer side a little to the left of the oospore at the extreme right, and another on the farther side a little to the right of the oospore at the extreme left. On the farther side there is also an antheridial site just to the right of the foremost member of the left hindmost pair of oospores.

TABLE 1.—*Reproductive contents of some preponderatingly female coenobia of Merrillosphaera africana at Manila.*

Specimen No.	Oogonidia or oospores.		Androgonidia, antheridia, or sites.	
	Number.	Size.	Number.	Size.
		μ.		μ.
9c	29	18-21	0	----------
9a	28	21-28	2	18
9b	15	21-28	2	18
8a	23	21-28	2	18
7a	23	25-29	3	19
10	29	30	2	19
14	32	37	2	----------
12	27	40	(?)	----------
13	31	41	3	----------
11	12	39-43	(?)	----------
15	27	43	2	----------

In this little series of coenobia with preponderatingly female reproductive bodies the number of oogonidia or oospores ranges from twelve to thirty-two as is shown in Table 1. Their greatest size before birth is about 29 μ. The ripe oospores are about 43 μ wide with a wall about 3 μ thick. Reproductive bodies are absent from the front of the coenobia. The androgonidia are two or three. Two form a pair, located on opposite sides of the middle of the coenobium, as are all of the larger gonidia of asexual coenobia. The androgonidia reach a size of only about 19 μ and divide before the birth of the coenobium containing them. The antheridium is a sperm platelet.

MALE COENOBIA

Coenobia that contain, besides the somatic cells, only large numbers of androgonidia that divide to form bundles or platelets of sperms were first described by Ehrenberg under the name *Sphaerosira volvox.* Since it has been recognized that these are the male coenobia of species of *Volvox* they have been known as the *Sphaerosira* stage of the species in which they occur.

That male coenobia of the *Sphaerosira* type occur in *Merrillosphaera africana* is demonstrated by specimen 7, in which asexual, bisexual, and male progeny occur in the same mother coenobium. Since the two species of *Merrillosphaera* occur mixed in most of the collections, description of the unborn males in their distinguishable mothers is more important than description of the free males concerning the identity of which there may be question. The only male coenobium in this little series of photomicrographs of typically ovoid coenobia at Manila will now be described.

Specimen 7b.—Plate 2, fig. 7. The unborn male coenobium in specimen 7 is of the same size and shape as its twin sister. It measures 265 by 383 μ in its flattened condition. The average spacing of the cells is between 21 and 25 μ. Taking it as 22.5 μ and the mean diameter of the coenobium as 302 μ, the number of cells indicated would be 6,500. The size of the somatic protoplasts ranges from about 4.5 μ at the back to about 7 μ at the front. The protoplasts of the twin sister coenobium are of the same size. Those of the smaller sister are all about 4 μ. Those of the mother coenobium range about from 6 to 7 μ. The area in the front that contains no androgonidia is small. The androgonidia are about from 12 to 15 μ wide and all undivided. It is estimated that in a given area they are about five times as numerous as the oogonidia of the twin sister. This indicates a number of about one hundred fifteen. They are scattered rather irregularly under the coenobium wall. Some are in pairs that are in contact, some in rows of three, and some form chains of cells that are not far apart.

The free male coenobium shown in Plate 2, fig. 8, is not from the same source as the material described. It will be considered with its associates as specimen 24.

FORMS WITH SOMETIMES MORE THAN FOUR GONIDIA

A FORM WITH SOMETIMES SIX GONIDIA

From the same pond, I, that supplied the material that included the specimens already described, there was obtained two

weeks earlier, October 5, 1914, material that has the distinguishing feature of embracing coenobia with six gonidia. Examples of these will be given as specimens 16 to 24. From a neighboring pond, J, on October 13 there was obtained material that included specimens 25 and 26, which also exhibit six gonidia. The slide bearing specimens 16 to 25 dried up before these coenobia were studied in detail. The specimens will be separately described for the purpose of bringing out points that may show better in the photographic prints than in the plates.

Specimen 16.—Plate 2, fig. 13. This is an asexual coenobium with two embryo daughters and two gonidia. The embryos are near the middle of the coenobium, one a little ahead of and the other a little behind it. They have the phialopores open. The gonidia are near the hindmost end of the coenobium.

Specimen 17.—Plate 4, fig. 21. This is another asexual coenobium in the same preparation. It contains two daughters and two very young embryos in pairs. So far as can be seen the reproductive bodies, gonidia, in the daughters are in number, relative size, and arrangement like those of the mother.

Specimen 18.—Plate 3, fig. 14. This is a specimen that was photographed on the same plate with specimen 16. It is an asexual coenobium with six reproductive bodies arranged in pairs. Two are embryos with their phialopores still open. They form a pair on opposite sides of the middle of the coenobium. Each of the other pairs of reproductive bodies consists of a gonidium and a few-celled embryo. One pair is a short distance back of the middle of the coenobium and nearly forms with the pair of daughters a square. The left body of this pair is the gonidium, and the right one the young embryo. The third pair is near the back of the coenobium; the left member is the embryo, and the right one is the gonidium. The diameters of the gonidia are about 50 μ.

Specimen 19.—Plate 4, fig. 23. This is a nearly mature asexual coenobium with six reproductive bodies that have proportions and arrangement similar to those of specimen 18 (fig. 14). Two pairs of larger but unequal daughters form a square in the middle, and one pair of smaller daughters is in the back part of the mother behind the members of the smaller middle pair. The conspicuous reproductive bodies in the daughters appear to be six gonidia in each of the middle daughters and four gonidia in each of the hinder pair. The gonidia of the larger daughters are proportioned and arranged like the daugh-

ters in the mother. Those of the smaller daughters are in two pairs like those of specimens 16 and 17 (figs. 13 and 21).

Specimen 20.—Plate 4, fig. 25. This is a similar but more-mature asexual coenobium. It contains a pair of larger, a single intermediate, and a pair of smaller daughters. All of the daughters appear to have four reproductive bodies except the left smaller one, which contains five. Whether the mother formed five daughters, or whether it had six, of which one had been born when the material was fixed, we cannot determine. In the former case it would resemble specimen 19 (fig. 23); in the latter it would resemble its pentagonidiate daughter.

Specimen 21.—Plate 4, fig. 24. This asexual coenobium and the next represent a form that presents a very different appearance from that of typical *Merrillosphaera africana.* The progeny are all practically of the same size. In these cases they happen to be male coenobia, each containing many androgonidia, or female.

Specimen 22.—Plate 4, fig. 26. An asexual coenobium with four female daughters. The daughters are so nearly of the same size that the gonidia from which they developed were probably nearly enough alike for the coenobium to be termed isogonidiate.

Specimen 23.—Plate 4, fig. 22. This is a female coenobium that contains, so far as we can see by the picture, twenty-five oogonidia. It measures 260 by 330 μ, and the oogonidia are about 27 μ wide.

Specimen 24.—Plate 2, fig. 8. This is a male coenobium with a large number of androgonidia. It is impossible to determine from the photograph whether or not the reproductive cells had divided. The vegetative area, if any, at the front of the coenobium is small. The coenobium measures about 270 by 350 μ, and the androgonidia are about 10 μ wide.

Specimen 25.—Plate 4, fig. 20. This and the next specimen were taken from Pond J, on October 13, 1914. This coenobium contains four daughters and one gonidium. The left of the larger daughters contains a pair of larger gonidia and a small one; the right one contains a pair of larger gonidia and a pair of smaller ones. Behind the right daughter there is an odd daughter that contains two larger and two smaller gonidia. In the back of the mother there is a small daughter containing likewise two larger and two smaller gonidia. This daughter is paired with a gonidium 54 μ in diameter. It may be noted

that the smaller daughter and the gonidium lie in a longitudinal plane perpendicular to that which passes through the larger daughters.

Specimen 26.—Plate 3, fig. 19. This is a nearly mature coenobium of the same preparation as the preceding. It measures 350 by 420 μ. The average spacing of the cells is about 12 μ, and the number of them is about 3,500. The protoplasts are ovoid and range about from 6 to 7 μ. The mother contains two elongated daughters that occupy the middle and back parts of the coenobium. Even with the hindmost ends of the daughters there are in the mother two abortive gonidia, one on the farther side and one on the nearer. These are about twice the size of somatic protoplasts and are sunken below the somatic layer. The daughters measure 110 by 160 μ and 90 by 105 μ. The larger one contains two granddaughters of 65 by 75 μ each, with a pair of gonidia measuring 48 by 50 μ and 40 μ near the middle and another pair of 50 μ and 42 μ near the hind end. The nearer granddaughter contains two larger and two smaller gonidia. The contents of the other are obscure. The smaller daughter contains two granddaughters and two gonidia of 45 μ each. One granddaughter contains two larger and two smaller gonidia, and the other is in an embryonic or pathologic condition with the phialopore wide open. Near the middle of the daughter there is a symmetrically disposed pair of rudimentary gonidia about 9 μ in diameter. Such a middle pair of vestigial gonidia is clearly lacking in the mother coenobium. On the same slide there are specimens with other combinations of daughters and granddaughters, and they include hexagonidiate coenobia that are more nearly mature and more nearly globular.

Specimen 27.—Plate 5, fig. 31. From Pond C in Pasay on September 20, 1914, material was taken of which some was fixed on the day of collection and some on the following day. Specimen 27 is among the latter. This is a very symmetrical hexagonidiate coenobium measuring 410 by 450 μ.[6] The protoplasts measure about 4 to 5 μ. The number of cells is about 5,000. The daughters of both middle pairs contain six gonidia each. The posterior daughters contain four gonidia each, and

[6] Five and a half years after the photograph was taken the dimensions had increased to 500 by 515 μ. Whether this is all due to additional compression or partly due to hydration of the membranes it is impossible to decide. The magnification of the figure is checked by a photograph of a stage micrometer that was made on the same plate with the same combination of photographic apparatus.

in each an abortive gonidium is visible, and there may be another in an obscure part. Between the two posterior daughters, on each side of the mother there is a cell somewhat larger than the somatic cells that may be interpreted as an abortive gonidium. One is about twice the diameter of a somatic cell and sunken, the other is about one and a half times the diameter of a somatic cell and not sunken.

Specimen 28.—Plate 5, fig. 32. This specimen is from the same material as the preceding but fixed on the first day mentioned. It has undergone partial disintegration since being photographed. It contains a pair of larger and a pair of smaller daughters, which in turn contain four gonidia each. The measurements of the gonidia are: 12.5, 13, 11, and 11 μ; 13, 13, 12, and 12 μ; 8.5, 9, 10, and 10 μ; and 8.5, 9, 9.5, and 9.5 μ.

Specimen 29.—Plate 5, fig. 37. From the same pond as the foregoing, about a month later, there came the material that included this specimen. It is very similar to the preceding specimen, but two of its four daughters are female. The asexual daughters contain, in the larger, two 8-celled and two 4-celled embryos; in the smaller, two 4-celled embryos and one gonidium in its first division and measuring about 46 μ. The female coenobia contain twenty-three reproductive bodies of 20 to 25 μ and twenty-four reproductive bodies of 18 to 23 μ, respectively.

Specimen 30.—Plate 5, fig. 33. This specimen and the two following are from the same material as specimen 27 (Plate 5, fig. 31). They were on a slide that dried up before notes were taken on the contents of the daughters. Specimen 30, a coenobium of 325 by 360 μ, contains two pairs of daughters, those of one pair somewhat larger (120 by 125 μ) than those of the other (90 by 100 μ). The contents of the daughters seem to be of the same type as of the mother.

Specimen 31.—Plate 5, fig. 34. This specimen shows a not uncommon combination of three larger and one smaller daughters. It is impossible to decide from the picture whether the smaller body in this case is a daughter or a gonidium. It measures about 50 μ.

Specimen 32.—Plate 5, fig. 36. This was selected as an example of coenobia having four daughters of nearly the same size. They are plainly arranged in pairs.

Specimen 33.—Plate 4, fig. 29. This is from the same lot as specimen 28 (Plate 5, fig. 32) and others. The mother is rather mature, and the daughters are backward in development.

There are two daughters and one embryo of sixteen cells. The daughters measured about 75 μ each, one containing gonidia of 22, 22, 16, 8, and 8 μ and the other of 25, 23, 8, 8, and 8 μ. The somatic cells of the daughters are ciliated and measure about 3.6 μ and are almost in contact. The number of cells in each daughter is about 1,570.

Specimen 34.—Plate 5, fig. 30. This was taken in September, 1914, from a carabao wallow, A, about 400 meters from the ponds previously mentioned. It contains four daughters, each with a pair of larger and a pair of smaller gonidia. In one of the larger daughters one of the smaller gonidia is extra small. The protoplasts of the daughters are about 5 μ wide and seem to be forming cilia.

Specimen 35.—Plate 5, fig. 38. This and the next coenobium are from carabao wallow B, near the one called A, in September, 1914. The specimen had dried up before being studied. However, the photograph is sufficiently clear to enable me to identify the contents of the daughters. Of the four daughters one is larger and the others are of nearly equal size. Each daughter contains two larger and two smaller gonidia, except one in which one of the smaller gonidia is extra small. In the smallest daughter two of the gonidia lie nearly one behind the other.

Specimen 36.—Plate 5, fig. 35. This is a young coenobium from the same slide as the preceding specimen. It contains at the left an advanced sexual embryo with the phialopore open. In the back there is a young asexual embryo with the phialopore open, and at the right there is an asexual embryo intermediate in development between the other two with the rim of the phialopore rolled outward and backward.

Specimens 37 and 38.—Plate 4, figs. 27 and 28. These are young coenobia with five and four embryonic daughters of which the phialopores are open. The specimens were crushed by glass rodlets that were intended for holding up the cover glass.

A FORM WITH SOMETIMES EIGHT GONIDIA

The largest number of asexual reproductive bodies in any of the specimens described in the preceding paragraphs is six, and their arrangement is in three pairs when that number is present. In material from the same collection as specimen 19 (Plate 4, fig. 23) I have seen, in a Venetian turpentine preparation that was stained too lightly for photography, one asexual coenobium with seven reproductive bodies. In this case the

additional member was a small gonidium in the back part of the coenobium. A collection made at Pasay on September 22, 1915, contained an abundance of a form that very commonly contains six, seven, or eight gonidia. It also contains smaller numbers, and when four are present they may be two slightly unequal pairs at about the same level, or one pair may be in the middle and a smaller pair in the back of the coenobium. Four specimens used in illustrating this material will show something of the range of the number of gonidia in this form by the gonidial content of their daughters.

Specimen 39.—Plate 6, fig. 39. This is a rather unique coenobium with six daughters arranged symmetrically in pairs. Only two of the daughters bear developed reproductive bodies. In each of these there is only one gonidium. There are a few very small reproductive cells in some of the daughters. It may be that these empty coenobia were to become males, but it seems to me that they were not preparing for any reproduction.

Specimen 40.—Plate 6, fig. 40. This coenobium had seven gonidia, of which six produced three symmetrical pairs of daughters and one a 16- or 32-celled embryo. The measurements of the mother are 320 by 400 μ.[7] The protoplasts are globular and measure from 5 μ at the back to 7 μ at the front. The average spacing of the cells appears to be about 10.7 μ and the number of cells about 3,800. The daughters by pairs are 150 by 170 μ and 142 by 160 μ, 125 by 138 μ and 125 by 145 μ, and 105 by 100 and 110 by 118 μ. The embryo, which has no mate, is about 55 μ wide and forms a hollow sphere with a small phialopore. The nuclei of all the cells of the sphere are at or near the inner ends of the cells. The daughters all contain gonidia. In the largest there are six of these: a pair of large ones, 55 by 58 μ and 53 by 57 μ; a pair of smaller ones nearly in the same plane as the first pair, 28 and 26 μ; and a pair intermediate in size, 41 and 35 μ, at the back of the coenobium. The mate to the largest daughter and one of the second pair each have a pair of large gonidia and two other pairs consisting of a medium and a smaller one. The other member of the second pair has a pair of large gonidia and a small odd one near the middle, and a medium and a small one at the back. The two

[7] In the photographs taken in 1916, the measurements of this coenobium are 350 by 460 μ. It is evident that these specimens in Venetian turpentine have shrunken until, in 1921, this one measures, under the microscope, 320 by 400 μ. That there has been shrinkage is made evident by the fact that the daughters in the coenobium are now nearer together.

small daughters have each four gonidia, in two pairs, large and small.

Specimen 41.—Plate 6, fig. 41. This is a coenobium that had eight gonidia that were arranged in four symmetrical pairs of different sizes. Those of the largest and next largest formed a square in the middle of the coenobium. Those of the third pair are behind and alternating with those of the two pairs in the middle of the coenobium. Those of the fourth pair were somewhat behind the members of the largest pair and were farther back than the third pair. The mother coenobium measures 350 by 370 μ.[8] The spacing of the cells averages about 10.7 μ. The number of cells is about 3,900. The protoplasts are globose and about 5 μ wide in the back and 7 μ wide in the front. The daughters are more nearly equal in size than those in the preceding specimen. Measurements of one of each pair are: 145 by 155 μ and 125 by 125 μ for the two pairs in the middle, 112 by 115 μ for the pair at the back, and 60 by 60 μ and 60 by 65 μ for the embryos. The pair of largest gonidia of each of the daughters in the middle group measure 50 μ; those of the daughters in the back of the mother, 46 and 39 μ. In the largest daughters there are six and five gonidia, and in the others four with the addition of one or two vestigial gonidia. The embryos are hollow spheres with open phialopores. The one nearest the observer consists of about one hundred sixteen cells. The somatogenic cells are about 7 by 9 μ in surface view. Two gonidia that can be measured are about 18 μ and 14 μ wide, the latter being nearer the phialopore. The indications are that the gonidia were formed at the 32-cell stage and showed their differentiation by not dividing when the somatogenic cells divided.

Specimen 42.—Plate 6, fig. 42. This coenobium is very similar to the preceding. It has six daughters in which the gonidia are in pairs and range from four to six with one or two vestigial gonidia in some of the cases, including both of those with six gonidia.

The forms here described with six, seven, and eight gonidia present no characters in the numbers, combinations, or arrangement of asexual reproductive bodies by which they can be distinguished from *Merrillosphaera africana*. Specimens 39 to 42, inclusive, are from a collection in which the coenobia were very abundant, formed almost a pure culture of the species, and presented a great variety of stages. A scanning of a preparation

[8] The dimensions in 1916, as indicated by the photograph, were 400 by 445 μ.

shows that the gonidia of the daughters almost all remain undivided until after the birth of the daughters. In some mothers there are four daughters that form a group without room for more behind.

There is an abundance of sexual and male coenobia in some material from the same source as specimens 16 to 24. The best of this is mounted in Venetian turpentine and stained too lightly for photomicrography.

One sexual coenobium similar to those of typical *Merrillosphaera africana* has five antheridia that are distributed in the coenobium to form two pairs near the middle and an odd one in a lateral position at the back. The arrangement is like that of gonidia in an asexual coenobium. Each of these antheridia forms a shallow cup of sperms or spermatogenous cells.

A small sexual coenobium was noted in the same mother with a somewhat smaller sister that contains two gonidia about 60 μ in diameter. This sexual coenobium contains twelve oogonidia and three androgonidia, the latter all in process of division and distributed like gonidia in an asexual coenobium, two in the middle and one at the back. The paired ones are 2- and 8-celled, and the odd one is 4-celled. The oogonidia measure about 32 μ.

Relatively mature oospores measure 35 to 39 μ. In these Venetian turpentine preparations none of the spores show any thickness of the spore wall.

Mixture of sexual and asexual reproductive bodies in the same coenobium was observed only once. In that case the coenobium contains three daughters and five oogonidia. The daughters are a pair in the middle and one at the back. Four of the oogonidia are grouped in that hind quarter of the coenobium left vacant by the lack of a mate to the smallest daughter. The fifth oogonidium is in advance of the middle daughters. The mother is 250 by 320 μ; the largest daughter is about 100 μ, and the smallest about 75 μ. The oogonidia range from 30 to 35 μ. The largest daughter contains four gonidia of from 18 to 22 μ. Its mate is somewhat smaller and contains three gonidia.

A SMALL FORM

A small form that is sometimes mixed with other species and sometimes forms almost pure cultures in the water has not been fairly represented in the micrographs that have been made. The only pictures of it are from the margins of plates used for larger species. They happen to be from Pond Q in Pasay on October 2, 1915. It is believed that they represent a diminutive

form that the species takes under conditions unfavorable to the development of robust coenobia. These specimens are in Venetian turpentine and considerably shrunken. In some lots in the same medium there appears to be very little shrinkage. The figured specimens (43 to 45) and some others (46 to 52) will be described.

Specimen 43.—Plate 6, fig. 43. This is a female coenobium with about twenty oospores of about 35 to 39 μ. It measures only about 200 by 240 μ.

Specimen 44.—Plate 6, fig. 44. This is an asexual coenobium with two daughters each containing two large gonidia and in one a third, very small gonidium. The mother is only about 150 by 160 μ, the daughters about 70 by 80 μ, and the gonidia about 15 μ.

Specimen 45.—Plate 6, fig. 45. An asexual coenobium with two daughters, each containing two large gonidia and one or two vestigial gonidia. The mother is 170 μ wide and 165 μ long; the daughters are about 80 by 100 μ; and the gonidia are about 25 μ in diameter. The polar regions of the mother coenobium are greatly shrunken by the mounting medium in this as well as in the preceding specimen.

Specimen 46.—Not figured. In a different lot of material, associated, apparently by accidental admixture, with forms resembling specimens 39 to 42, that are not shrunken in mounting, there is a coenobium of the same kind as specimens 44 and 45 having an even more-compact appearance. It measures 170 by 180 μ, has two daughters of about 80 by 120 μ, and in each two gonidia of from 42 to 50 μ.

The small forms are very abundant in collections IV and V made at Pasig, near Manila, in August, 1914. Some descriptive data pertaining to six coenobia of this material will be recorded here. The first five are in Venetian turpentine, and the last is in glycerine. A comparison of the material in the two media seems to show that there is more shrinkage in the Venetian turpentine than in the glycerine.

Specimen 47.—This is a mother coenobium that was selected because it was thought to contain only one daughter. Closer examination revealed the outer outline of the capsule of an absent daughter. This capsule is a little shorter than that of the present daughter. No place of exit of the absent daughter could be seen. The remaining daughter occupies a little more than its share of the space within the mother. The mother measured 170 by 180 μ. It consists of about 5,300 cells packed closely to-

gether with a spacing of about 4.5 μ. It has not been free more than a short time. The daughter is 105 by 110 μ with cells closely packed and spaced about 3.5 μ. The number of cells indicated is about 3,400. It contains two developed gonidia and some vestigial ones. The gonidia are 50 by 55 μ and 48 by 52 μ, and their combined diameters reach entirely across the cavity of the daughter, so that the gonidia are in close contact in the center.

Specimen 48.—This is a mother with two daughters each having two gonidia. The mother is much wider than long, 220 by 170 μ. The daughters are 120 by 140 μ and 115 by 135 μ. The gonidia in the daughters are 70 and 75 μ in one and 68 by 76 and 65 by 70 μ in the other. These are the largest gonidia recorded in this paper.

Specimen 49.—This is a mother with two asexual and one female daughters. The mother is 270 μ wide and 240 μ long. The daughters are 130 by 140 μ. They contain two gonidia in two and twenty-five oogonidia in the other. The dimensions of the gonidia are 60 by 67 and 65 by 70 μ in one and 68 by 70 and 65 by 67 μ in the other daughter. The oogonidia are about 16 μ wide. In the first daughter one gonidium is dividing, and the other is about to divide as shown by the nuclei. Before dividing the nucleus moves from the center to the outward side of the gonidium.

Specimen 50.—This is an asexual coenobium with three daughters; a pair of larger ones that are male and female, and a smaller one that is female. The mother measures 190 by 230 μ, the male coenobium 130 by 140 μ, and the females 130 by 150 μ and 90 by 120 μ. In the larger female the oogonidia number twenty-seven and measure 18 to 25 μ, and in the smaller one there are eighteen oogonidia that measure from 12 to 18 μ. In the male coenobium the androgonidia are about 9 to 11 μ in diameter, and they are so numerous that they form an almost continuous layer, except in a small area in the front of the coenobium where there are none. The number of the androgonidia is about three hundred fifty.

Specimen 51.—This was selected as an example of a rather small female coenobium. It measures 165 by 190 μ in Venetian turpentine and contains fifteen mature oospores. These have a smooth wall 43 μ in diameter and apparently about 2.5 μ thick. The inner boundary of the wall is not visible in this mounting medium. Within the wall the densely granular part of the protoplast is 29 μ in diameter and touches one side of the wall.

There are also present in the coenobium four empty capsules about 29 μ wide that are either the remains of abortive oogonidia or empty antheridia.

Specimen 52.—This specimen is selected from among a bewildering variety on the same slide because it exhibits characters of asexual and sexual coenobia in two daughters of the same age. It is in glycerine, and the material with it shows very little sign of shrinkage; the specimen in question, none at all. The mother is 350 μ wide and 320 μ long. The protoplasts range from about 4 μ at the back through 5 μ in the middle to about 6 μ at the front. The average spacing of the cells is about 7 μ, and the number of cells is about 7,500. The two daughters are 150 by 200 and 160 by 200 μ. The former contains two granddaughters, and the latter seventeen oogonidia and two androgonidia. The granddaughters are 70 by 88 μ and 70 by 90 μ, and each contains two gonidia of about 15 μ in diameter. The sexual daughter has the oogonidia about 12 to 15 μ wide, and the androgonidia, located on opposite sides of the middle, are smaller. One of these is undivided and about 8 μ wide. The other has formed a platelet of many sperms. This platelet is 7 μ thick and about 20 μ wide.

It is thought that the descriptions given will suffice for a fair picture of *Merrillosphaera africana* as it has been found at Manila. Extended search would undoubtedly reveal variations beyond the ranges of numbers and dimensions furnished by the material described. As an example, an exceptional coenobium was seen with three daughters and five bodies that had all the appearance of oogonidia. Another example is a very small coenobium, 126 by 152 μ, that contains five sperm platelets and seven oogonidia.

SUMMARY

The chief facts added to our knowledge of *Merrillosphaera africana* by the account of the typical form of the species as found at Manila are as follows:

1. The somatic protoplasts are not connected by protoplasmic filaments.

2. The gonidia are differentiated at a very early stage in the segmentation of the embryo.

3. The gonidia reach a considerable size before dividing; commonly about 55 μ, sometimes even 75 μ.

4. The gonidia form pairs whose members are about equal in size and are located symmetrically on opposite sides of the polar axis.

5. The largest, or only, pair of gonidia is about in the middle of the coenobium.

6. The additional gonidia are smaller and in the back of the coenobium.

7. When four gonidia are not present, absent pairs or members are commonly represented by abortive or vestigial gonidia.

8. When two pairs of gonidia are present there is sometimes a rudimentary third pair between the members of the first pair.

9. The sexual coenobia are of three kinds; bisexual, female, and male.

10. Asexual coenobia and sexual coenobia of the different kinds may be produced by the same mother in any combination.

11. In the bisexual coenobia the androgonidia are few and smaller than the oogonidia.

12. In the bisexual coenobia the androgonidia occupy positions like those of the gonidia in asexual coenobia; that is, two are on opposite sides of the middle of the coenobium and the third, with the fourth if there be one, is in the back part of the coenobium.

13. The androgonidia divide at about the time of birth of the coenobium and form platelets of sperms.

14. The female coenobia are like the bisexual, but without androgonidia.

15. The oogonidia are decidedly smaller than the gonidia.

16. The androgonidia are smaller than the oogonidia.

17. The male coenobia contain large numbers of androgonidia that divide at about the time of birth of the male coenobium or afterward.

18. The antheridia are platelets of sperms.

From the forms with six and those with eight gonidia the following points appear:

19. Forms occur with two pairs of gonidia that are nearly alike in size.

20. In forms with six gonidia the second pair is in the middle and its members alternate with those of the first pair.

21. In forms with eight gonidia the fourth and smallest pair is at the back and alternates with the third pair.

22. The bisexual coenobia sometimes have four antheridia distributed around the middle of the coenobium and one or more farther back.

23. The platelets of sperms sometimes take the form of shallow cups.

REVISED DIAGNOSIS OF THE SPECIES

In my first paper dealing with the genus *Merrillosphaera* there is given a diagnosis of *M. africana* drawn entirely from the accounts by West ('10 and '18) of the African material. Since the forms here described all seem to belong to the same species, the diagnosis of the species will be expanded to embrace them.

MERRILLOSPHAERA AFRICANA (West) Shaw.

Volvox africanus West in Journn. Quekett Micr. Club II 11 (1910) 102–103, *pl. 3, figs. 8–10*; II 13 (1918) 425–428, *pl. 29, figs. 4–6.*

Coenobia ovoid to ellipsoidal; ranging from 295 by 345 to 500 by 600 μ. Number of somatic cells between 3,000 and 8,000. Somatic protoplasts almost globose; 4 to 9.5 μ in diameter; widely separated in the front and grading to much closer at the back of the coenobium. Gonidia, 1 to 8; reaching 53 to 75 μ in diameter; in pairs of different sizes; the largest pair on opposite sides of the middle of the coenobium; other pairs successively smaller; the second of two pairs usually in the back of the coenobium; the second of three or four pairs usually in the middle of the coenobium between the first pair. Gonidia of daughters sometimes divide and produce granddaughters that are the beginning of the fourth generation while the daughters are still within the mother. Daughter coenobia strongly ovoid and more or less flattened by mutual pressure. Granddaughters at first spherical. Bisexual coenobia producing 2 to 6 antheridia with 12 to 43 oospores. Oogonidia more numerous and smaller than gonidia in sister coenobia. Oospores with thick smooth walls; diameter about 43 to 45 μ. Female coenobia like the bisexual. Male coenobia with between 100 and 400 antheridia; androgonidia smaller than oogonidia of same or sister coenobia; front of coenobium without reproductive cells. Antheridia in the form of platelets or shallow cups. Spermatozoids not described.

Habitat.—Albert Nyanza, Africa (*leg.* R. T. Leiper, 1907); Ussangu Desert, German East Africa (*leg.* A. W. Jakubski, 1909–10); fresh-water pools near Manila, Philippine Islands (*leg.* W. R. Shaw, 1914).[9]

[9] Slide mounts of material of this species from the vicinity of Manila have been sent to Prof. Douglas H. Campbell, Stanford University, California, and to Prof. Frank G. Haughwout, Bureau of Science, Manila, P. I. Material bottled in glycerine has been sent to sixteen biologists in Europe and Asia and to sixteen in America. Duplicates of this bottled material are available for distribution from my United States address: Claremont, California.—W. R. S.

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ILLUSTRATIONS

[The figures on Plates 1 to 6 are photomicrographs of *Merrillosphaera africana* (West) Shaw and of new forms of the species, found at Manila, from specimens mounted in glycerine, unless otherwise noted, taken by W. R. Shaw and E. Cortes at the Bureau of Science, Manila. Those on Plate 7 are somewhat enlarged reproductions of the photomicrographs of African material that were made by G. S. West and used to illustrate his two papers in which this species was originally described.]

PLATE 1

FIG. 1. An asexual coenobium of the typical form of *Merrillosphaera africana*. This is the youngest coenobium represented on the plate. It measures 330 by 410 μ and contains one daughter with two gonidia (nonsexual reproductive cells). The gonidia are both about 30 μ wide. Specimen 1. × 100.

2. Another asexual coenobium of the same form. This is the most-nearly mature coenobium on this plate. It measures 460 by 520 μ and contains two daughters, each with one gonidium and one embryo. From left to right the third generation are: A gonidium of 53 μ; an 8-celled embryo of 54 μ; a gonidium of 53 μ; and a 2-celled embryo of 53 μ. Specimen 2. × 100.

3. A somewhat younger coenobium of the same form. It measures 430 by 540 μ and contains two asexual daughters, each with three gonidia. The four larger gonidia from left to right are 60, 57, 53, and 53 μ, and the two smaller ones are 46 and 42 μ. Specimen 3. × 100.

4. A coenobium of the same form that is the next to youngest on the plate. It measures 345 by 425 μ and contains two daughters, each with four gonidia. The larger gonidia, from left to right, are 38, 35, 38, and 40 μ, and the smaller ones 22, 20, 22, and 24 μ. Specimen 4. × 100.

5. A coenobium of the same form, measuring 365 by 450 μ, with two daughters that contain four and three gonidia. In the left daughter one gonidium of 33 μ width is mostly behind another of the same size, and the two small gonidia are about 20 μ wide. In the right daughter the larger gonidia are about 30 μ and the small one is about 20 μ wide. Specimen 5. × 100.

6. Another coenobium of the same form, measuring 450 by 540 μ, and having three daughters. The gonidia in the left daughter are about 50, 50, 30, and 30 μ; in the right daughter 48, 40, 32, and 32 μ; and in the hindmost 32, 30, and 18 μ. Specimen 6. × 100.

PLATE 2

FIG. 7. An asexual coenobium of the same form of *Merrillosphaera africana* as all of those on the preceding plate. It measures about 450 by 550 μ, but bulges greatly on account of pressure of the cover glass. It contains three offspring, one bisexual at the

left, one male at the right, and one asexual at the back. The bisexual daughter contains twenty-three oogonidia (female reproductive cells) of 25 to 29 μ in diameter and three androgonidia (cells that produce male elements) of about 18 μ width. The male offspring contains about one hundred fifteen androgonidia that are about 12 to 15 μ wide. Specimens 7, 7*a*, and 7*b*. $\times$ 100.

8. A male coenobium found associated with a different form of the species that is represented by Plate 2, fig. 13, Plate 3, fig. 14, and Plate 4, figs. 21 to 26, inclusive. It measures 270 by 350 μ and the androgonidia are numerous and about 10 μ wide. Specimen 24. $\times$ 100.
9. An asexual coenobium of the typical form. It measures 460 by 560 μ (bulging greatly on account of cover-glass pressure) and contains a bisexual and an asexual daughter. The bisexual daughter contains twenty-three oogonidia of 21 to 28 μ diameter and two androgonidia of 18 μ diameter. The latter are at the left and right sides of the daughter. The asexual daughter contains two embryos, one 8-celled and one 4-celled, that were formed from large gonidia, and one smaller gonidium of about 46 μ in diameter. Specimens 8 and 8*a*. $\times$ 100.
10. A nearly mature sexual coenobium of the typical ovoid form. It measures 360 by 460 μ and contains twelve oospores that range from 39 to 43 μ wide. The spore walls are smooth and about 3 μ thick. Specimen 11. $\times$ 100.
11. An immature bisexual coenobium of the typical ovoid form. It measures 320 by 405 μ and contains twenty-nine oogonidia of about 30 μ in diameter and two androgonidia. One of the latter, in the right side of the coenobium and hidden by an oogonidium, is 19 μ wide. The other, at the left side above the middle, is divided into an immature platelet of thirty-two cells that measure 26 μ across. Specimen 10. $\times$ 100.
12. An asexual coenobium of the typical ovoid form. In its very bulging condition, due to cover-glass pressure, it measures 560 by 600 μ. It contains three sexual daughters in which female reproductive bodies preponderate. The left daughter contains twenty-eight oogonidia of 21 to 28 μ diameter, and two androgonidia, each about 18 μ wide. The right daughter contains fifteen oogonidia and two embryonic antheridia (sperm platelets or bundles of sperms) that are developing from androgonidia. One, at the left, is 4-celled, and the other, at the right, is 2-celled. The small daughter contains twenty-nine reproductive bodies 18 to 21 μ wide, among which no androgonidia are distinguishable. Specimens 9, 9*a*, 9*b*, and 9*c*. $\times$ 100.
13. An immature asexual coenobium of the 6-gonidiate form that is shown in Plate 2, fig. 8, in Plate 3, fig. 14, and in Plate 4, figs. 21 to 26, inclusive. It is 290 by 325 μ in width and length, and contains two embryos and two gonidia. The embryos have the phialopores open. The gonidia are about 45 by 50 μ in diameter. Specimen 16. $\times$ 100.

PLATE 3

FIG. 14. An immature asexual coenobium of the same form of *Merrillosphaera africana* as those shown in Plate 2, figs. 8 and 13, and Plate 4, figs. 21 to 26, inclusive. It measures 370 by 390 μ and contains two advanced embryos with open phialopores, two very young embryos, and two gonidia. The young embryo that is the left member of the lower pair is 2-celled, that which is the right member of the upper pair is 4-celled. The gonidia measure about 50 by 52 μ and 50 by 55 μ, the inequality of the dimensions indicating preparation for division. Specimen 18. $\times$ 100.

15. A nearly mature sexual coenobium of the typically ovoid form. The dimensions are 500 by 585 μ, and the reproductive bodies are twenty-seven oospores. Specimen 12. $\times$ 100.

16. An oospore of the same coenobium, slightly out of focus, and the overlying somatic cells. The outside diameter of the spore is 40 μ. The diameters of the somatic protoplasts in sharpest focus are a little more and a little less than 5 μ. This spore is the one in the left side and nearest the front of the coenobium and is out of focus in the preceding figure. Specimen 12. $\times$ 400.

17. Another sexual coenobium of the same form. It measures 470 by 520 μ and contains thirty-one oospores that are not quite mature. A little above and to the left of the center an empty antheridial site may be seen. Specimen 13. $\times$ 100.

18. Four oospores from the same coenobium. The somewhat wavy appearance of their walls is due to shadows of overlying somatic cells. Diameters of spores about 41 μ. Specimen 13. $\times$ 400.

19. An asexual coenobium of a 6-gonidiate form, of which a younger one is shown in Plate 4, fig. 20. It was about 350 by 420 μ in breadth and length. The bulging of the sides is probably due to cover-glass pressure. The left daughter contains two granddaughters and four gonidia in pairs. The right daughter contains a granddaughter, an embryo, and two gonidia. In each daughter the nearest granddaughter contains four gonidia in pairs. Specimen 26. $\times$ 105.

PLATE 4

FIG. 20. A younger asexual coenobium of the same 6-gonidiate from of *Merrillosphaera africana* and from the same source as the one shown in Plate 3, fig. 19. It measures 230 by 290 μ and contains four daughters and one gonidium. Behind the right larger daughter there is a smaller one. The gonidium, 54 μ wide, is paired with the smallest daughter. The left daughter contains three gonidia. Specimen 25. $\times$ 105.

21. An asexual coenobium from the same source as the specimens shown in Plate 2, figs. 8 and 13, Plate 3, fig. 14, and Plate 4, figs. 21 to 26. It contains two daughters and two very young embryos. The daughters contain gonidia proportioned and arranged as were those of the mother. Specimen 17. $\times$ 100.

22. A sexual coenobium of the same form with about twenty-five oogonidia. Specimen 23. $\times$ 100.

23. A nearly mature asexual coenobium of the same 6-gonidiate form. The six daughters form three pairs of different sizes. The daughters all contain gonidia. Specimen 19. × 100.
24. An asexual coenobium of the same form containing four male coenobia that are nearly equal in size. Specimen 21. × 100.
25. The most-nearly mature asexual coenobium of this lot. It measures 470 by 570 μ. The left side is partly hidden by the shellac ring of the mount. Specimen 20. × 100.
26. An asexual coenobium of the same lot with four much-crowded sexual daughters, all apparently female, but possibly bisexual. Specimen 22. × 100.
27. A nearly globular asexual coenobium from another source. It contains two daughters that have the phialopores open, and three gonidia or young embryos. Specimen 37. × 100.
28. An asexual coenobium from the same source as the preceding. It contains four nearly equal daughters with the phialopores still open. Specimen 38. × 100.
29. A nearly globular asexual coenobium from the same source as those shown in Plate 5, figs. 31 to 34 and 36. It contains two daughters and one embryo. Each of the daughters contains four gonidia. Specimen 33. × 100.

PLATE 5

FIG. 30. An asexual coenobium of *Merrillosphaera africana* different in source from all the others. Each of the daughters contains four gonidia in pairs. Specimen 34. × 100.
31. An asexual coenobium of the 6-gonidiate form. It is 410 by 450 μ. The four larger daughters contain six gonidia each, and the two smaller ones four each. Specimen 27. × 99.
32. An asexual coenobium from the same source as that of the one shown in the preceding figure. The daughters each contain four gonidia. Specimen 28. × 100.
33. An asexual coenobium from the same source as the preceding. Specimen 30. × 100.
34. Another asexual coenobium from the same source. Specimen 31. × 100.
35. A young coenobium from the same source as that shown in fig. 38. It contains three embryos. Specimen 36. × 100.
36. An asexual coenobium with four daughters of nearly equal size. This is from the same source as those of figs. 29, and 31 to 34. Specimen 32. × 100.
37. An asexual coenobium from the same source as those of figs. 29, 31 to 34, and 36. It contains two asexual and two sexual daughters. The asexual daughters contain four and three embryos in 2- to 8-celled stages. The sexual daughters contain eighteen and twenty-three reproductive bodies. Specimen 29. × 100.
38. An asexual coenobium from the same source as that of fig. 35. The daughters all contain gonidia. Specimen 35. × 100.

PLATE 6

FIG. 39. An asexual coenobium of an 8-gonidiate form of *Merrillosphaera africana*, as are those of the three following figures. These are all mounted in Venetian turpentine. This coenobium contains six daughters, and in all of them the only developing reproductive bodies are two gonidia that are in different daughters. Specimen 39. × 100.

40. An asexual coenobium of the same form as that of the preceding figure. It contains six daughters in pairs, and an odd young embryo. The daughters contain only gonidia. Those in the larger daughters are 53 to 58 μ wide. Specimen 40. × 100.

41. An asexual coenobium of the same form as that of the two preceding figures. It contains six daughters and two embryos of about one hundred sixteen cells each. In the largest daughters there are six and five gonidia; in each of the others four. Specimen 41. × 100.

42. An asexual coenobium of the same form as that of the four preceding figures. It contains six daughters. One large daughter contains six, the other large one and a smaller one each five, and the other smaller daughters each four gonidia. Specimen 42. × 100.

43. A sexual coenobium of a small form of the species in Venetian turpentine. It is from the same source as those of the two following figures, and they are all mounted in the same medium. It contains about twenty oospores of 35 to 39 μ diameter. Specimen 43. × 100.

44. An asexual coenobium from the same source as that of the preceding and following figures. It is considerably shrunken by the process of mounting in Venetian turpentine. It contains two daughters, each with two gonidia. Specimen 44. × 100.

45. Another asexual coenobium from the same lot. It contains two daughters, each with two robust and one or two vestigial gonidia. Specimen 45. × 100.

46. An immature bisexual coenobium of the typical 4-gonidiate ovoid form of the species shown by Plate 1 and Plate 2, figs. 7 and 9 to 12, inclusive. It measures 410 by 515 μ. The reproductive bodies are thirty-two oogonidia about 37 μ in diameter and an antheridium, a little to the left of and above the center, consisting of a sperm platelet. Specimen 14. × 100.

47. The most mature of all the bisexual coenobia that are figured in these plates. It measures in the picture 515 by 620 μ. It is greatly compressed under the cover glass, and its dimensions before compression were probably nearer 500 by 600 μ. In it there are twenty-seven oospores. They have smooth walls about 43 μ in outside diameter and 37 μ in inside diameter. There are three antheridial sites; two at the middle level on opposite sides of the coenobium, and another in the back part of the coenobium. Specimen 15. × 100.

PLATE 7

[All of the figures on this plate are reproductions, somewhat enlarged, of photomicrographs that were made by the late Prof. George Stephen West, of the botanical department of the University of Birmingham, and used to illustrate his two papers in which this species was originally described from African material.]

FIG. 48. An asexual coenobium of *Merrillosphaera africana* from Albert Nyanza, Africa. It measures 475 by 595 μ and contains three daughters with three, four, and four granddaughters or embryos, respectively. In the larger granddaughters gonidia are visible. × 100.

49. An asexual coenobium from the same source, measuring 455 by 525 μ, and containing three daughters with three, two, and two granddaughters or embryos, respectively. × 83.

50. Another asexual coenobium from the same source, measuring 420 by 490 μ and containing four daughters, each with four gonidia or embryos. × 83.

51. A sexual coenobium from the Ussangu Desert, in what was formerly German East Africa. It measures 565 by 660 μ and contains about thirty-nine oospores. The most distinctly visible spore wall measures, according to the magnification stated, about 51 μ. × 88.

52. Another sexual coenobium from the same source, measuring 600 by 780 μ, and containing about forty-one oospores. × 88.

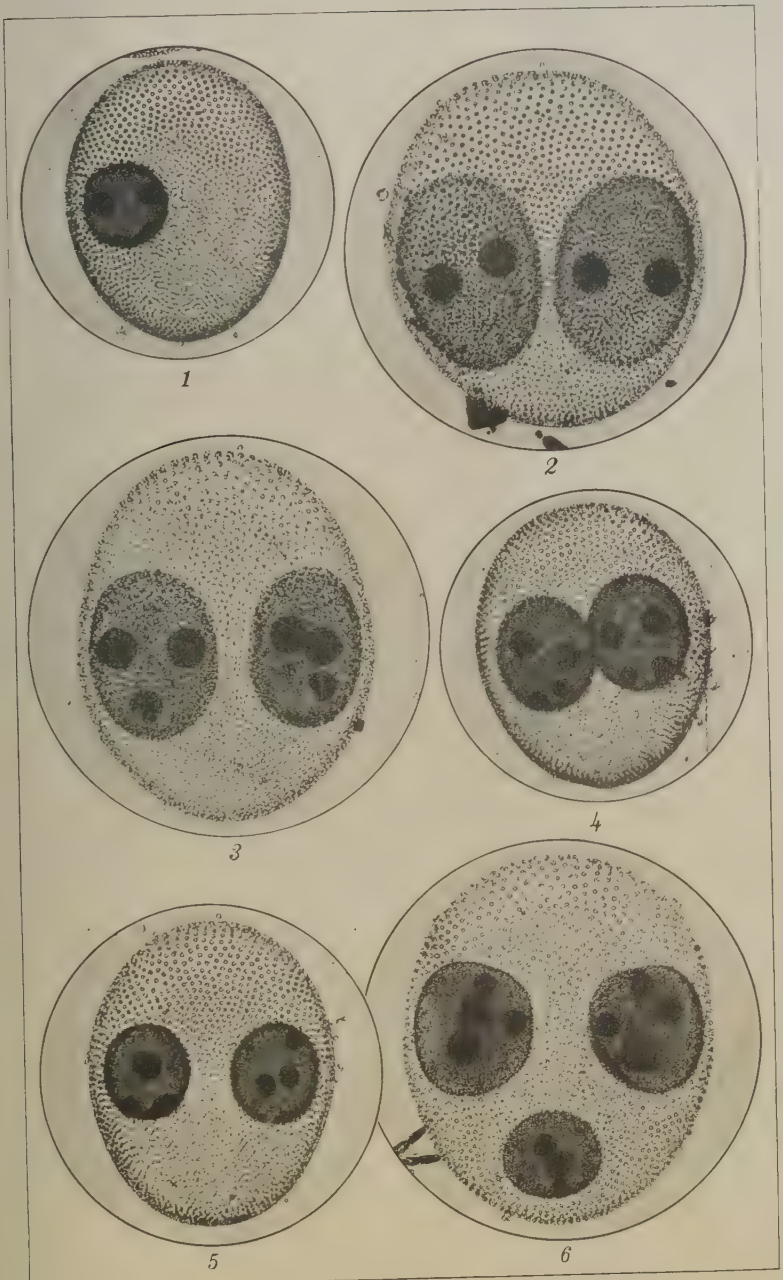

PLATE 1. MERRILLOSPHAERA AFRICANA (WEST) SHAW.

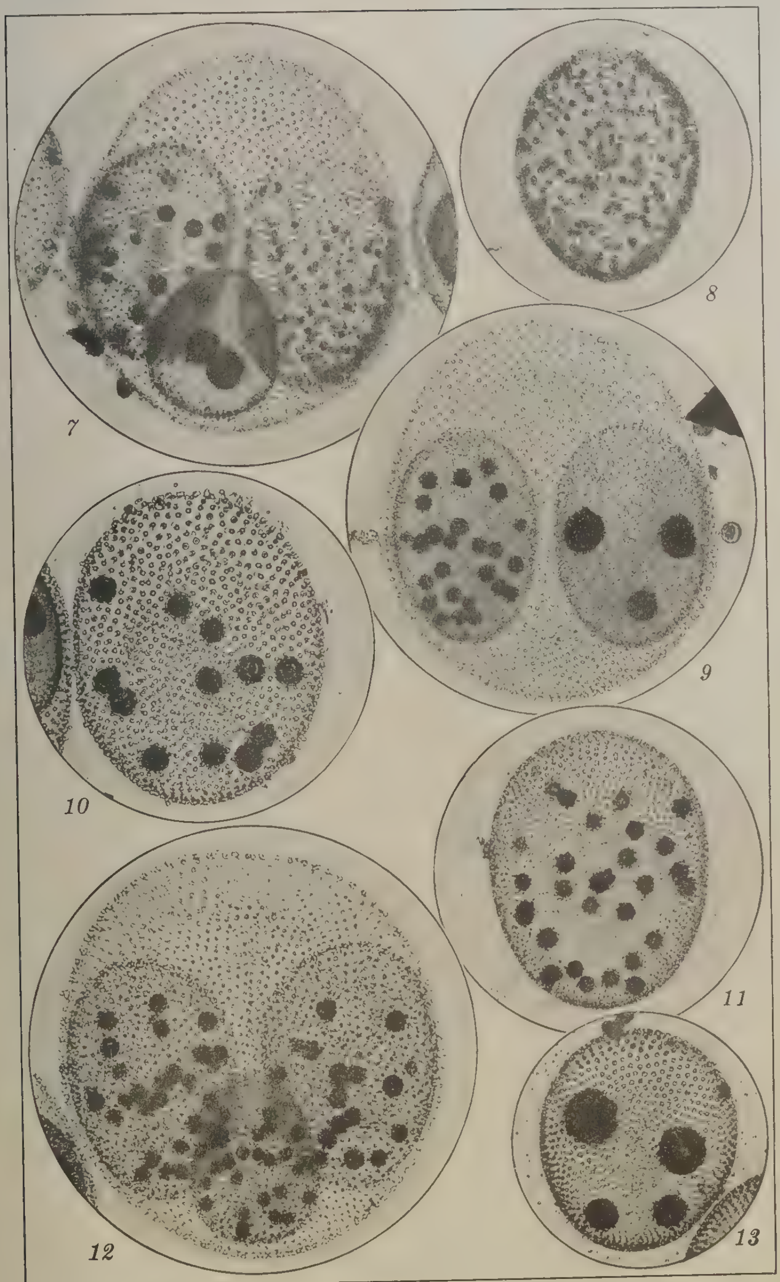

PLATE 2. MERRILLOSPHAERA AFRICANA AND RELATED FORM.

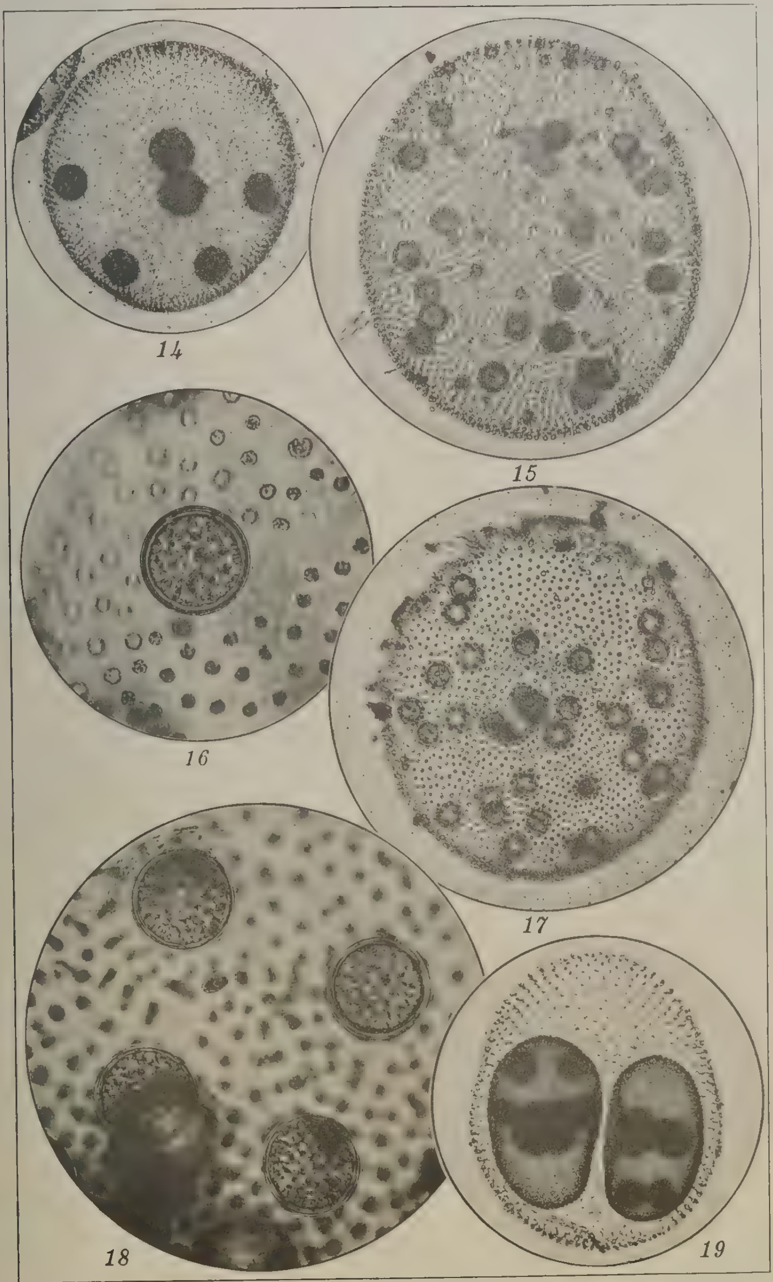

PLATE 3. MERRILLOSPHAERA AFRICANA AND RELATED FORM.

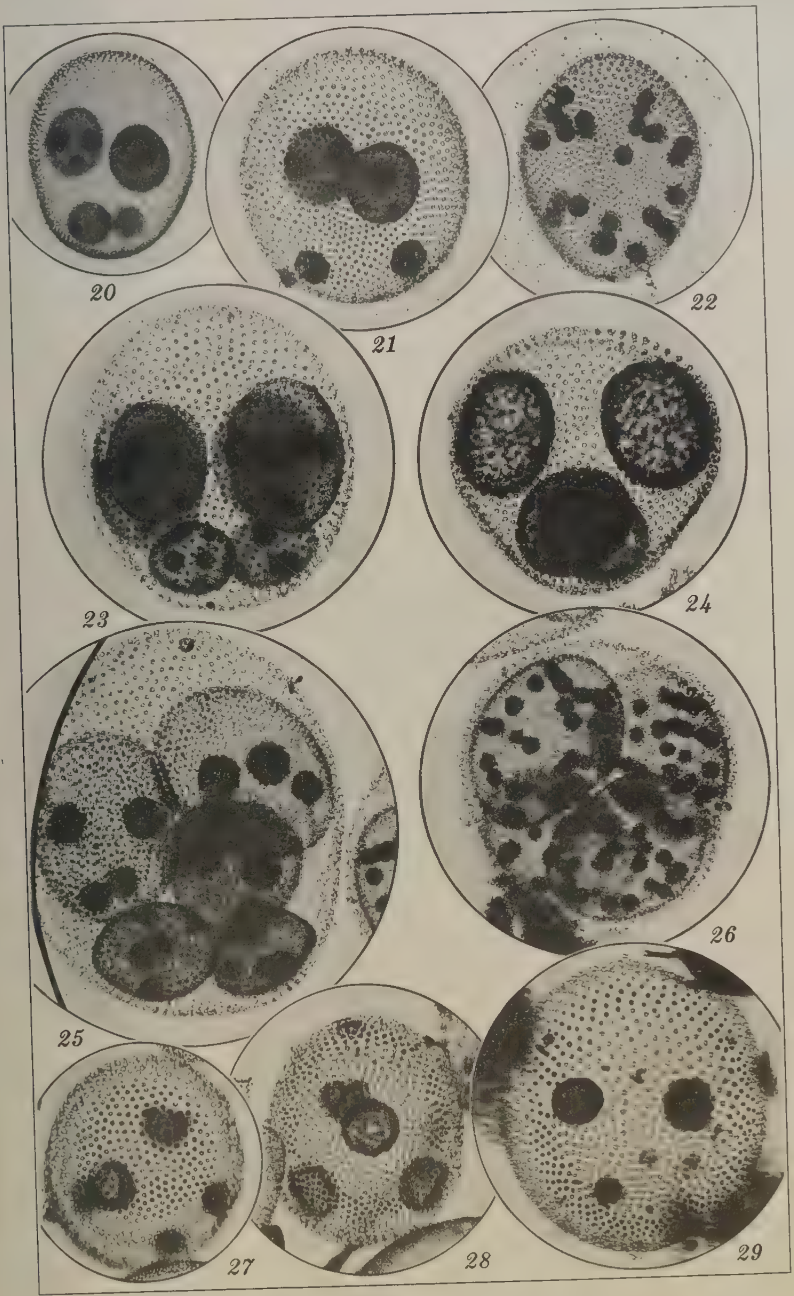

PLATE 4. MERRILLOSPHAERA.

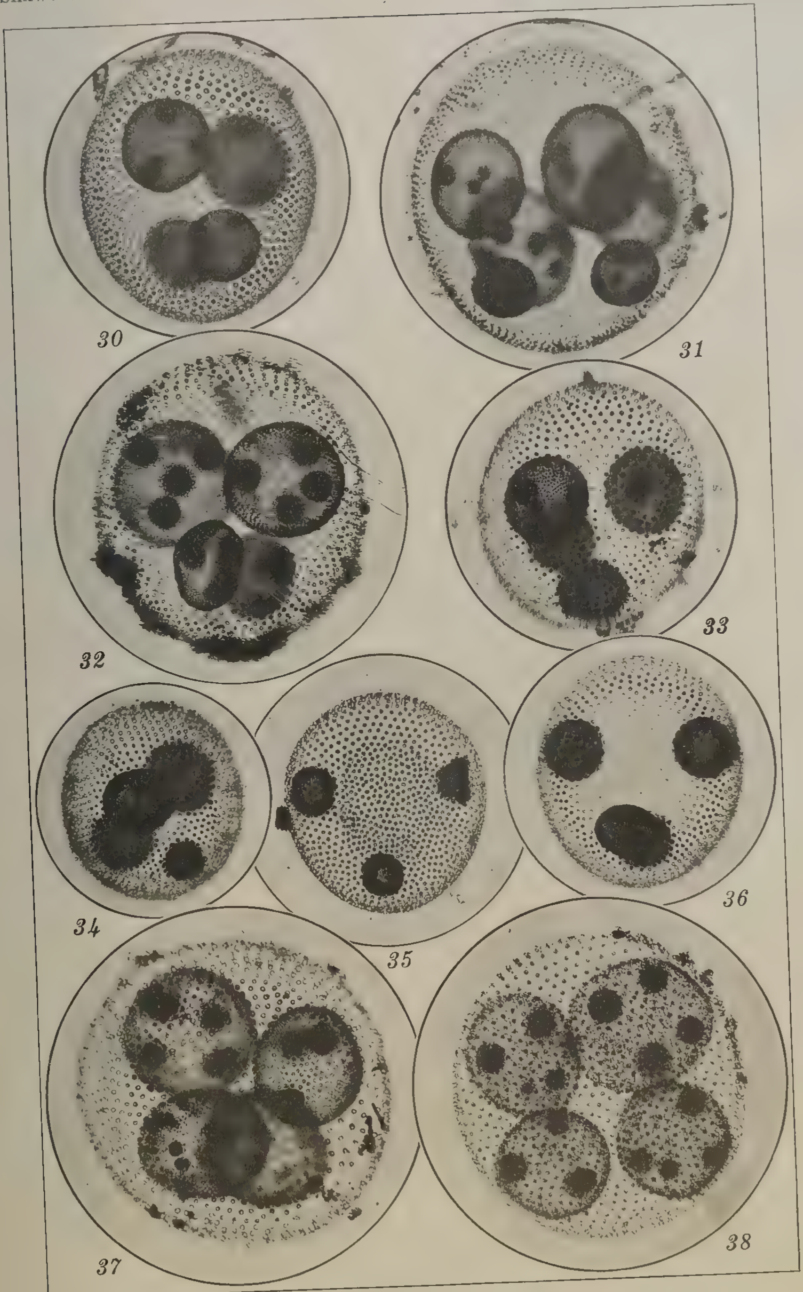

PLATE 5. MERRILLOSPHAERA.

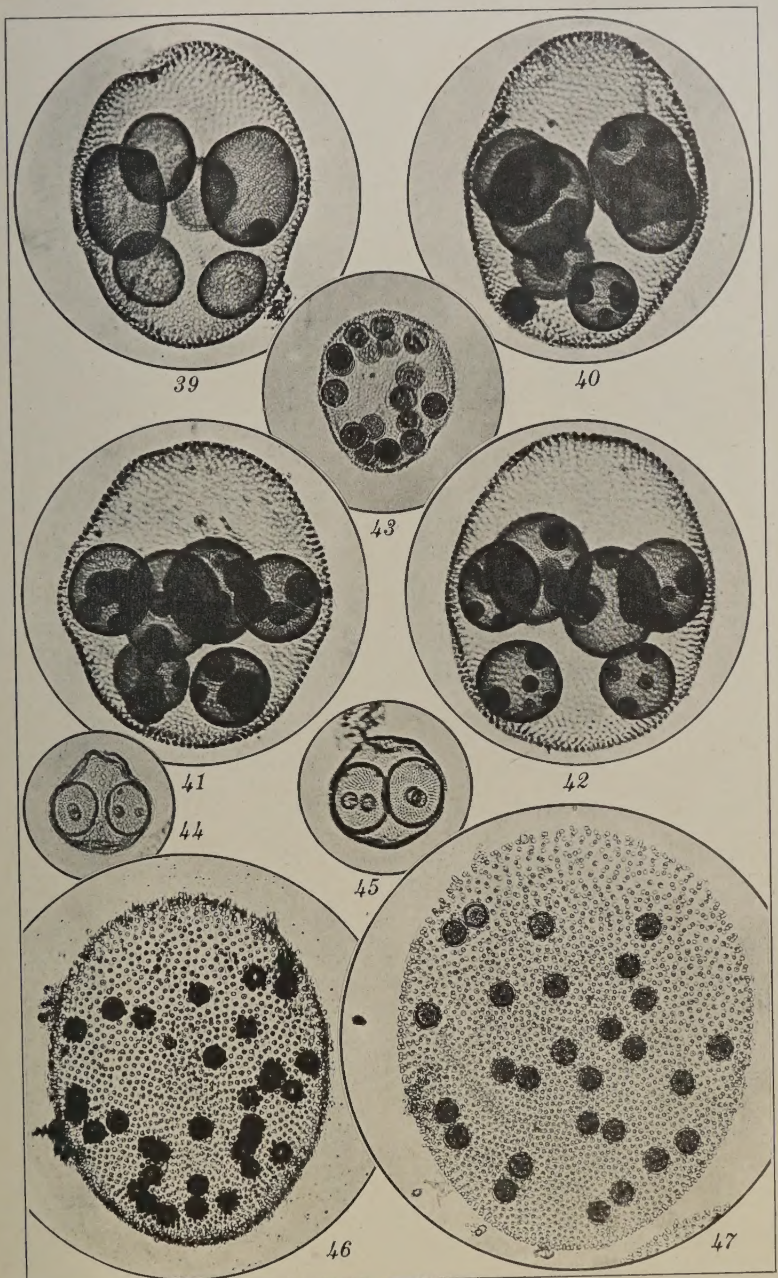

PLATE 6. MERRILLOSPHAERA AFRICANA AND RELATED FORM.

PLATE 7. MERRILLOSPHAERA AFRICANA (WEST) SHAW.